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IMPROVING BED MANAGEMENT AT WRIGHT-PATTERSON MEDICAL CENTER

THESIS

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R. Daniel Cheek

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ABSTRACT

The purpose of this study was to analyze bed management at Wright-Patterson Medical Center. The research had three objectives: (1) Examine the admissions and dispositions process. (2) Determine the hospital staff's perspective on the problem. (3) Determine if the number of beds was adequate for demand. The research methodology consisted of interviews, a staff questionnaire, and a simulation study.

The research found some aspects of the admissions and dispositions process that were easing bed management problems. However, poor communication between departments as well as with patients, and lack of clear lines of authority and responsibility over the bed management process made bed management more difficult. The hospital staff generally agreed there were bed management problems, citing lack of personnel, inability to determine Emergency and Aero Evac arrivals, and not enough beds as major contributors to the problem. The simulation showed the Medical Center had enough beds to meet 1988 demand levels, and scheduling based on a historical mean would not improve bed usage. Some of the recommendations were to improve communication, return authority and responsibility for beds to the Admissions and Dispositions office, and begin a long term scheduling solution.

IMPROVING BED MANAGEMENT AT WRIGHT-PATTERSON MEDICAL CENTER

I. Introduction

General Issue: Bed Availability

Bed management is an extremely important dimension of hospital administration. The level of bed occupancy provides a highly visible, surrogate measure of the hospital's ability to make maximum use of its services. Bed management is mainly a issue of capacity control. When considering maximizing profit and customer service, the goal is to keep every bed filled to capacity--a 100 percent occupancy rate. In direct opposition to this goal is the mandatory requirement to maintain some excess capacity to meet emergency medical demands. These conflicting requirements greatly complicate the problem. This research will focus on the bed management process at the Wright-Patterson Medical Center, and attempts to identify several means for improvement.

Historical Concern. The concern for better bed management has generated numerous actions at Wright Patterson Medical Center (WPMC). This concern has increased over the last year and a half. In October 1987, the Director of Hospital Services moved responsibilities for bed scheduling from the Admissions Office to the major clinical specialties (Randolph, 1987). In addition, three administrators were assigned to investigate three different aspects of bed management and to make recommendations. A year later, in the fall of 1988, the hospital commander prepared a letter for all incoming patients (Roadman, 1988), which explained that the hospital's construction project might cause bed availability problems. Shortly after that letter, in January of 1989, a new Director of Hospital Services prepared a letter for all incoming patients discussing the bed shortage issue. He asked the patients to vacate their bed within two hours of discharge, and to wait for their transportation in a hospital waiting area (Murray, 1989). Most recently, in the Spring of 1989, a Process Action Team (PAT) consisting of 12 members representing multiple areas of WPMC, was created to review the bed management problem. All of these actions have demonstrated the Medical Center Administration's concern for better bed management.

In November 1988, Colonel Tuttle, Director of Process Quality Review, Wright-Patterson Medical Center (WPMC), stated that some patients scheduled for inpatient hospital care were dissatisfied. The patients complained they arrived in the morning and were delayed until late in the day to receive a hospital bed (Tuttle, 1988). They often waited in the Admissions and Dispositions Office (A&D) or returned home until a bed was available (Meccia, 1988). Some patients with baggage visited hospital labs during the day and returned to A&D later in the afternoon to get a bed assignment. Realizing this could be a continuation of the bed management issue, and could be affecting the customer service philosophy of the hospital, Colonel Tuttle asked that this research evaluate the situation.

Personal interviews with hospital staff as well as a thorough literature review revealed bed management is an almost universal problem for hospitals. Bed management is an issue because a balance must be maintained between the efficient use of resources, and providing quality medical care. To make efficient use of resources, hospitals would like to predict the future demand for beds as well as manage the scheduling of beds on a daily basis. Complicating both goals are seemingly random and endless fluctuations in uncontrollable variables. Critical care patients often arrive unexpectedly. Opposite gender, or illness of patients, are additional constraints which affect bed assignment. Several patients scheduled for release might suddenly require a longer stay. The medical staff must consider all of these variables and more when determining whom to admit, to which ward, and on what day.

Specific Problem

The specific problem is that bed management affects the ability of the hospital to provide quality medical care. In order to address the problem, the following research question was asked: What can be done to improve bed availability at Wright-Patterson AFB Medical Center?

Investigative Questions

To guide the research effort, the research question was further defined by asking three investigative questions. Those questions were:

1. How does the current admissions and dispositions process operate at Wright-Patterson Medical Center?
2. Do hospital administrators think there is a bed management problem, and if so, what factors do they think affect bed availability?
3. Can a simulation be created that will accurately model the bed management process?
   a. What is the profile of a typical patient?
   b. What are the arrival sources?
   c. Is there a pattern of arrivals by day of week?
   d. Is there a pattern of arrivals by week of year?
   e. Is there a pattern of arrivals by month of year?
   f. What is the average length of stay of patients by clinical service?

Research Objective

The purpose of this research was to determine what factors could be changed at WPMC to improve bed availability. Cost and mission interruption made manipulation of real variables prohibitive. Therefore, an alternative method of investigation was to design, assemble and manipulate a simulation program to model the Wright-Patterson Medical Center bed management process.

An advantage of using a simulation is "the researcher must become thoroughly familiar with the process in order to model it accurately" (Cobbin, 1987).

Using this model as a baseline, critical variables were manipulated to discover their effect on the process. Critical variables were determined from a review of the literature, interviews with Wright-Patterson Medical Center hospital administrators and from personal observation and experience. Those critical variables were: 1) capacity, 2) length of hospital stay, and 3) number and source of admissions. Length of stay appeared dependent on the patient, the physician, and the type of illness. Therefore, the length of stay variable was ruled out as a variable the hospital could readily manipulate. However, the capacity of bed space, and scheduling of admissions might be controllable and were decided upon as variables to manipulate. Two prototype models were designed and tested prior to initiation of this objective.

Scope And Limitations

This study was limited to the bed management operation of the Wright-Patterson Medical Center. The study examined the unique admissions and dispositions process of WPMC, and therefore may not be applicable to other settings without modifications. It pertains to a nonprofit, government-operated, service organization.

Ideally, a study takes into account all variables affecting the system. There were, however, limitations to the study.

Time was a major restriction. There were time limitations on acquiring data, analyzing the material and writing the results. The study had to be completed relatively quickly to allow implementation of the results while the results were still relevant.

Another limitation was in the depth of the research. Most information about the process of bed management was gained through personal interviews. Personal interviews were good because they increased the depth of knowledge about the process. This method of research also yielded details not available with other methodologies. However, interviews required great time and effort to obtain and analyze. The time factor required to gather data limited the number of respondents and therefore the completeness of the information gained. Since information gained from the interviews was from a limited number of respondents, generalization of the data to a larger population may be questionable. The information gained was collaborated in order to improve its reliability (Emory, 1985:98, 166). The best information would have been objective, quantifiable, and complete. Interviews are limited in these three areas.

However, complete information is sometimes available. A database may provide close to 100 percent of the known information about a variable of interest. Wright-Patterson Medical Center has such a database on all patients which includes detailed information on 9,396 admissions in 1988 (AdHoc Report, 1989). This type of information is objective, quantifiable, complete, and would greatly expand the depth of knowledge. However, using *all* the information in the database provided was not always practical.

One impracticality was gaining access to the database. The Wright-Patterson Medical Center computer staff was not able to download the database information to magnetic tape for transfer to another computer for statistical analysis. The possibility of transferring the data by electronic means was also ruled out. The remaining option, working on the database within the hospital computer, was not authorized.

Obtaining a printout of all the needed information was a possibility. Using a printout, however, had several drawbacks. Manually inputting all the printed information into a new computer database increased the likelihood of transfer errors. Also the time factor associated with getting the data into a usable form, analyzing the data with available software, and manipulating the data was prohibitive. An alternative to using a large database directly was to statistically sample the data from the printout.

Finally, there are breadth limitations. Every factor affecting the bed management process appeared important. However, many of those factors could not be modeled due to restrictions. Some breadth restrictions were simulation program limitations, researcher knowledge, and usefulness to the study.

Other breadth limitations were availability of data not on the database, willingness of the hospital staff to offer information, and willingness of the hospital staff to undergo scrutiny. These limitations forced the researcher to narrow the process down to critical elements that could be modeled realistically, accurately, and reliably.

Thesis Overview

Bed availability has always concerned the medical profession. Wright-Patterson Medical Center has an additional Aero Evac workload other hospitals do not have. WPMC is a USAF Regional Medical Center and services several states. When a local military hospital in this region has a patient with a medical problem requiring expertise beyond their capabilities, the patient is flown to WPMC for treatment.

Generating solutions to the problem of bed management required an investigation into the history of the problem both at WPMC and in the industry to determine how the problem had previously been handled. Chapter II addresses that need. Chapter III explains the methodology used in the research process. The results of the study are presented in Chapter IV and conclusions and recommendations are addressed in Chapter V.

Definitions

Admissions. Admissions are divided into three types: direct/urgent (Emergency), planned admission (Scheduled), and

Aero Evac. Direct/urgent admissions are those who need admission within 72 hours. For the purpose of this thesis, direct/urgent admissions will be called Emergency admissions. Planned admissions are those that could be admitted within one to four weeks (Brown, Sarmiento, Levy, 1983:50). These can be scheduled into the hospital. For the purpose of this thesis, planned admissions will be called Scheduled admissions. Aero evac admissions are those patients arriving at WPMC from other localities. They need hospital admission as soon as possible after arrival.

Available Bed. The bed is both physically empty and "unoccupied" (Meccia, 1989).

Blocked Bed. "A blocked bed is a bed occupied by a patient who, in the consultant's opinion no longer requires the services provided for that bed, but who cannot be discharged or transferred to suitable accommodation" (Hall and Bytheway, 1987).

Clinic. In this thesis, the terms *clinic, clinical specialty, clinical service, medical service* and their various singular/plural forms are all synonyms. They refer to that specific portion of the hospital, other than A&D, that gives specialized care to inpatients.

Occupied. A patient is assigned to a bed. It is possible for a patient to be admitted to the hospital and released on a temporary pass lasting several days. Even though the bed the patient used is empty, it is still considered occupied under current policies. Therefore, the bed is not "available" (Meccia, 1989).

Preadmission. The process of conducting tests and examinations on an outpatient basis prior to the admission of elective patients (Martin, Dahlstrom, Johnston, April 1985:66).

Ward. When the term is used during discussions of the literature review or the hospital in general, a ward has its traditional meaning of a *physical* holding place for beds. When the term is used during discussions of the simulation, a ward is theoretical. It is those beds assigned to a clinical specialty regardless of where those beds are physical located. In the simulation, clinical specialty is synonymous with ward in meaning those beds assigned to a particular clinical specialty.

II. Literature Review

During research into bed management at Wright-Patterson Medical Center (WPMC), information was obtained from two major sources. First, information about the history of bed management at WPMC was necessary in order to understand the current problem. This information is included in the first major section of this chapter and was obtained from an analysis of the official and unofficial written records. Second, information from an industry perspective was needed to outline how the problem has historically been handled in the industry. For this purpose, literature relevant to hospital bed management was extracted from medical journals and is included as the second major section of this chapter.

Hospital Records

Bed shortages have been a major concern for over a year at WPMC. Three different hospital administrators, Knoop, Wong, and Sakosky, all working simultaneously, examined different aspects of bed management and tried to find solutions to WPMC's bed management problem (Sakosky, November, 1987).

Knoop. In October 1987 Knoop said the bed shortage problem would last a year. At that time, he said major hospital construction caused overbooking of patients. Ward availability made planning for admissions difficult. The result of the confusion was a first-come, first-serve bed scheduling process.

There was no priority structure and neither patient nor provider could make admission and treatment plans. Knoop decided the bed scheduling process would work better if scheduled by physicians themselves. Therefore, in October of 1987, the scheduling process was changed so the Nursing Coordinator no longer controlled beds. Instead the Admissions and Dispositions office "called attending physicians/chief residents to take action to place their patients in a bed" (Wong, November, 1987). Figure 1 depicts the changed process.

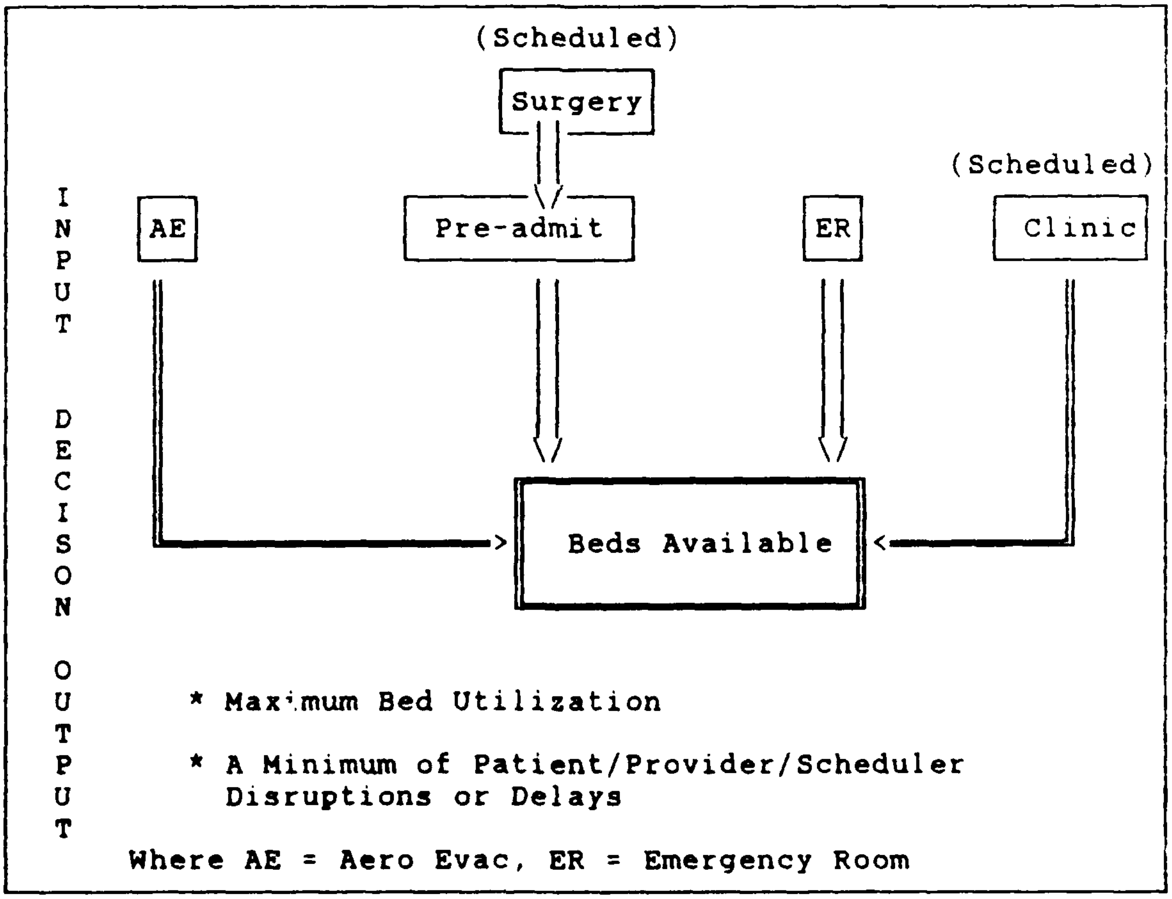


FIGURE 1: BED ALLOCATION SOLUTION (Knoop, 1987)

Knoop thought the hospital should maximize bed numbers and categories of patients while minimizing patient/provider/ scheduler dissatisfaction, delay and schedule change. To implement this objective he made four recommendations. The first recommendation was to develop a predictive model that considered the surgery schedule, a bed reservation system, and improved projections of staffing requirements. His second recommendation was to develop a real-time, information system to forecast short-term discharging. His third recommendation was to clarify lines of communication and responsibility. Lastly, Knoop suggested the problem be publicized.

Concerning the surgery schedule, Knoop advised the immediate implementation of a manual predictive model for the current day plus 24 hours as well as an information system using the "existing mechanisms." He thought someone should look into an automated predictive model and information system.

Wong. Wong (October 20, 1987) researched the affect of Aero Evac arrivals on the bed availability problem. She tabulated types of Aero Evac patient diseases and averages of arriving Aero Evac patients. She recommended WPMC inform the Aero Evac regulating office at Scott AFB, IL of the service limitations WPMC was experiencing and to limit incoming Aero Evac patients to attempt to control the uncertainty of arriving patients.

Wong also looked at the admissions process. She found there were three ways to control the number of beds available. WPMC could control Aero Evac arrivals, preadmit admissions, or discharges. She also found three preadmit admissions: "only admissions", "same day admissions", and "last minute patients".

"Only admission" patients had completed all but one preadmit test. They were ready to be physically admitted. Wong said those patients should arrive at the Medical Center no earlier than 1000.

"Same day" admissions were patients who had not accomplished lab work or an admission history prior to admission. Those patients usually arrived by 0730 so they could access labs before the labs became overcrowded by outpatients.

"Last minute" patients were those who were directed to admissions by physicians without prior coordination. Last minute patients made up 20 percent of the final admissions list.

Wong (November, 1987) said department chiefs met and discussed the bed shortage problem in the fall of 1987. They discussed their perception of the problem: while many patients arrived at 0700, they were not placed in a bed until late afternoon. The Patient Administration Office was tasked to develop a predictive model for bed modeling. The Director of Hospital Services sent out a policy letter (Randolph, 1987) prioritizing patients, disallowing sharing of beds between services, directing that patient discharge orders be written before 1100, and directing the early submission of a preadmit form (AF Fm 560) (Wong, November, 1987).

Some changes to procedures occurred. One change was "bed status reporting was modified [on] 22 October to [occur at] 0730 and 1500 since 0730 reflects status for the day and 1500 is used to project for next day per Charge Nurse info" (Wong, November, 1987). Another change was the surgery department began to monitor their own beds.

Wong made other observations related to patient admissions by keeping notes on her own hospital admittance. She said admission into the hospital began at 0750 with a briefing and ended nearly eight hours later at 1540 when she reached her room. She stated that the walk to the lab, X-ray, and EKG was long, tiring, and confusing. The wait in X-ray and in the Perri Room was stuffy and boring. She questioned the need to talk with the OR nurse since it appeared to repeat the preadmission interview. Finally she said that though patients found the hospital very pleasant, there was a sense of desperation when a bed was not available.

Wong made the following observations about the admissions and dispositions system (Wong, November, 1987).

1. On two days, two patients were sent home at 1500 (for a total of four patients during the month of October 87).
2. Medicine was short beds on 6 days, and surgery was short beds on 12 days (during the month of October 87).
3. The one attempt at cancelling preadmits the day before admission was time-consuming and depended on having the phone numbers of patients. The Director of Hospital Services discontinued this procedure until the information process could be improved.

4. The modified bed status reports, reduced from four daily reports to two at 0730 and 1500, was working. However, Wong did not define "working".

5. Hospital awareness of the bed shortage apparently resulted in a decrease in the number of preadmits per day and a decrease in clinical admissions.

6. Rather than having patients wait for a bed, patients were sent for pre-op tests during the day and sent to lunch if a bed was not available.

7. Preadmit began counseling patients to arrive later. That way patients got their own meals and waited less.

8. However, patients admitted later in the day put a heavy burden on the unit doing preparation procedures.

9. Same day preadmit procedures took all day but the patient had no place to leave belongings or wait comfortably if a bed was unavailable.

Wong (October, 1987) recommended a booklet be given to potential inpatients explaining arrival times, possible delays and reasons for those delays. This would sensitize the patients to the problems they might encounter during admissions. She encouraged the preadmission office to review arrival times with the patients. She thought better coordination between clinics and preadmissions would help, as well as a maximum admissible, patient cutoff number each day. Wong suggested the discharge time of 1100 be enforced except for certain surgeries. Discharging patients by 1100 would allow the bed to be available by 1300 for a new patient. If the bed would not be available by 1300, then Wong suggested elective surgery patients be sent home.

One month after the 5 October 1987 "bed crunch", Wong concluded

> (A) Combination of physician sensitivity to (the) problem, reinforcement of preadmit procedures, patient education, action to decrease patient inconvenience, and establishing more controllable variables (i.e. Aero Evac) will sufficiently address the bed crunch (Wong, November, 1987).

<u>Sakosky</u>. The third administrator to examine the bed shortage by Sakosky (October 1987). Sakosky evaluated the possibility of automated scheduling. She found two area hospitals, Miami Valley and Good Samaritan had considered scheduling models but had not implemented them. Her investigation also revealed that none of the 65-member Southwest Ohio Admissions Managers (SWOAM) group had an automated scheduling model. These hospitals had decided models were to complex too implement. In fact, day-to-day scheduling was the rule. Local hospitals preferred using historical data and effectively managed discharges to handle bed management issues.

Sakosky concluded physicians should handle their own scheduling of beds since the physician would "naturally" act in his own best interest and handle beds efficiently (Sakosky, November, 1987). Another conclusion reached by Sakosky (January, 1989) dealt with using a predictive model at Wright-Patterson Medical Center. Such a model would require up to a year of high quality data. It seemed unlikely to her the Medical Center could spare an individual to keep those records.

Sakosky recommended changing several policies dealing with discharges (Sakosky, 1987; 1989). One reason beds were not available was because some patients who were released by the physician, delayed leaving their room. Some patients who were waiting for a ride insisted on remaining in their room until the ride arrived. Other patients were waiting for an Aero Evac aircraft. Sakosky advised that the policy of discharging patients as early in the day as possible be enforced, and that a clear discharge time and policy for patients be established. An in-house holding area for those discharged patients would allow the patient to clear the hospital room and still wait at the hospital as long as necessary.

Sakosky (1989) recommended policy changes in other areas. In admission policies, she thought most oral surgery could be done as an outpatient service. (in 1988, oral surgery inpatients still numbered 216 patients). Since Aero Evac patients were such an uncertainty, possibly an absolute number limit could be set to aid planning. In disposition policies, she suggested patients who could not return to work for health reasons, but did not need doctor's care, should be out processed earlier to home care (Sakosky, November, 1987). For long stay patients, review and justification of each case on a regular basis would ensure beds were used wisely.

Summary Of Efforts To Date. Even though three administrators each examined the bed management process, they were able to do little to change the system. The reason for the difficulty in changing the system became obvious after a review of the literature on the subject was done. Bed management problems are complex and industry wide, with solutions as varied as there are hospitals.

Periodicals As A Literature Source

The information gleaned from Wright-Patterson Medical Center personnel serves as a backdrop on which to examine the industry literature. Literature found in medical journals addressed bed management issues from many different angles.

Preadmissions. Prior to admitting a patient, several things can be done to improve bed usage. By completing testing prior to admission, the overall hospital stay is shortened, thus making beds available earlier. The testing process, called preadmissions, is "the process of conducting tests and examinations on an outpatient basis prior to the admission of elective patients" (Martin et al., April 1985:66).

A preadmission review program can free up beds according to Greater Southeast Community Hospital administrators Brown and Levy (1983). In this system, admissions are divided into two types: Emergency and Scheduled. Emergency cases are reviewed and challenged to ensure they are really necessary. If it is determined they are not urgent, the case may be changed to a

Scheduled admission. For other than Emergency admissions, surgeons must file bed reservation forms when they post cases for surgery. The request for a bed reservation was also reviewed, and sometimes the request for a bed was refused. Some of those cases were changed from inpatient to outpatient care and some cases were transferred to other hospitals. During the initial phase of the program the hospital's average length of stay decreased from 10 to 8.2 days.

Admissions Processes Can Be Improved. Another area a hospital might want to examine is the admission process. In one hospital, some patients waited two to five hours until beds were available, admitting processes were not coordinated, too many employees were dealing with the patient, and there was no personalized service (Testolin and Byers, 1978:107). To solve those problems, non-medical patient responsibilities were centralized into one position called a business representative. Business representatives performed patient liaison activities such as expediting admissions, handling discharges, arranging transportation, and supervising bed cleaning. The personalized admitting system cut the door-to-bed admission time to 11 minutes and in-house patient transfers by 50 percent. Agreeing with the idea that activities should be centered in one person or in one office, Hardy (1986:27) suggested one-step administration processing increases efficiency and cost effectiveness. One step processing occurs when patient administration activities are consolidated. He recommends patient accounting, registration, admitting, medical records, and other patient-related clerical activities be combined in one clinic (Hardy, 1986:27; Pehkonen, 1985:70).

Sadilek (1984) discussed a hospital that had frequent phone calls interrupt the admitting process. To deal with the interruptions a recording device took calls while admission clerks processed patients. The recorder took critical information and gave an alternative number in case the caller needed personal service. The device increased scheduling accuracy, allowed scheduling to be done during slack evening hours, eliminated interruptions of the registration interview, and increased the number of pre-registrations accomplished, thus shortening the interview process at the time of registration (Sadilek, 1984:24, 25).

Shukla (1985) found an admissions system based on monitoring case mix was more effective than an admissions system based on monitoring census. However, both types of monitoring were better than a system without a monitoring function at all (Shukla, 1985:92). Many early admissions systems required forecasting length of stay or discharges which required a predictive model. This was difficult. Shukla noted that monitoring work flow much like a factory monitors products worked better. It minimized idle time and used personnel efficiently.

Whatever the method used to improve admissions, the admissions process is greatly improved when it is personalized. Personalizing the process relieves anxiety the patient feels (Gil and Phillips, 1984:26). The goal of the hospital is to care for patients even in the midst of being efficient.

Who Should Handle Scheduling? While some hospitals want the Admissions Office to handle scheduling, Langelle (1987) evaluated the policy of giving physicians the authority to manage beds. He thought this would remove competition caused by physicians trying to get beds. In his plan, the beds were not physically allocated to physicians, but each physician was allowed a maximum number of patients on any particular service, ward or unit with a minimum number of beds remaining open for emergencies. Maternity, day surgery and ICU beds were excluded, and some beds were shared by physicians. A physician could exceed his allocation by borrowing from another doctor without hospital involvement.

Determining Occupancy. Once the decision of who should handle bed scheduling is resolved, a hospital must know how many beds it needs. This is the process of determining occupancy. A bed is considered occupied if a patient is using it both before and after midnight (Sellu, 1984). This does not account for patients who occupy beds outside that parameter, even though the patient has used resources.

Occupancy level is the average bed use of all beds in a hospital. The average occupancy rate in the US, not including nursery beds, is between 73.4 percent (Hancock, Martin, Storer, 1978:25) and 76 percent (Phillip, Mullner, Andes, 1984:53). The 76 percent occupancy implies an idle capacity of 24 percent. Phillip et al. claim this is fine. They say this safety margin allows for Emergency arrivals and idle capacity and is, in a way, productive. Since hospital care is a service, it can only be consumed when needed. Without idle capacity, service cannot be given and needs can not be met. The importance of this idle capacity service overrides normal managerial decisions such as economies of scale, location, or size (Phillip et al.).

What factor(s) should be used to determine occupancy? One hospital forecasted occupancy by comparing advanced reservations to actual admissions, then used a percentage of the difference to forecast the next week's admissions (O'Connor, 1978). Some authors suggest occupancy levels should be based on census fluctuations (MacStravic, 1982) while Phillip et al. (1984) said there is a uniform occupancy rate for hospitals. Phillip et al. said uniformity is obvious because hospitals manage to maintain a protection level by setting beds aside for Emergency arrivals. Other factors that affect the protection level hospitals set are hospital size, the number of non substitutable patient facilities, the percent of elective beds, the number of hospitals serving an area, and the relative variation in demand. Still other factors that affect occupancy levels are percentage of cancellations and turn aways, days per week of scheduled admissions, and days per week of call-in admissions (Martin et al., April 1985:68).

Gianfrancesco (1980:260) believes a major effect on hospital occupancy is specialization. He says specializing lowers bed occupancy. Reducing specialization will reduce the variation of admissions over time and reduce required bed capacity resulting in cost savings. He notes specialization allows for higher quality care and the probability that a greater use of expensive equipment would occur. Similar to the idea of reducing specialization is reducing ward divisions (Dundas and Meechan, 1986). Dundas and Meechan determined that if beds were pooled into fewer wards, higher rates of occupancy would result.

Determining The Correct Number Of Beds. It is necessary to determine the correct number of beds to meet demand. If too many beds are open there will be higher operating costs, yet if there are too few beds, there will be a lack of quality health care (Hancock et al., 1978:25). As a guideline, Hancock found the average size of a "productivity-excellent" hospital was 287 beds. A popular approach for determining bed planning in Canada is a formula based on a uniform and known population assessed by health officials (LeTouzé:123).

The length of stay of a patient directly impacts the number of beds available for incoming patients. But what influences the length of stay? One factor is the availability of beds. Strauss, LoGerfo, Yeltatzie, Temkin, Hudson, (1982:1143) found patients admitted and discharged to ICU wards during times of high bed occupancy were more ill than those admitted and discharged during times of low occupancy. Doctors rationed beds such that patients discharged during times of high occupancy had shorter lengths of stay than when occupancy was low. Another factor affecting length of stay was the time of admissions.

Patients admitted after 1500 had a longer hospital stay (Cannoodt and Kinckman, 1984:585). This was not due to illness related factors. Cannoodt and Kinckman found Friday and Saturday admissions lead to longer preoperative and postoperative stays. Government-owned hospitals had a one day longer postoperative stay than did voluntary hospitals. Whether a hospital was operating for profit or for nonprofit might seem to affect length of stays of patients, but one author found there was no significant difference in length of stays between investor owned and voluntary hospitals (Freund, Schachtman, Ruffin, and Quade, 1985).

Though the length of stay impacts hospital beds, predicting those stays is difficult. Some hospitals try instead to predict the number of beds needed. Prediction depends on the type of ward and the prediction technique being used.

Predicting acute care beds depends on three variables: (1) the number of hospital admissions; (2) the average number of days those admissions stay in the hospital, or the average length of stay (ALOS); and (3) the average occupancy level of available beds expressed as a percentage. The relationship between these variables is:

$$\text{Required beds} = \frac{(\text{Annual admissions})\ (\text{ALOS})}{(\text{Average occupancy})\ (365)}$$

Where: ALOS = Average Length of Stay

(Martin et al., April 1985:63)

If a hospital wants to estimate how many beds it needs, then they could input the known variables into the formula to calculate the number of beds needed. However, if capacity is capped, then one of the other parameters must change. If average length of stay or number of admissions is reduced, or average occupancy increased, there will be a reduction in the number of required beds.

Goplerud (1986) looked at how requirements for psychiatric beds were predicted in 16 hospitals. Some common methods used to predict the number of beds needed were expert opinion, historical use, epidemiological data, and social indicators. He found a mixture of all methods provided a more reliable predictor than any single method. Expert opinion was the worst predictor followed by historical demand.

Goplerud found an average of 50.6 licensed acute psychiatric beds per 100,000 population with an average occupancy rate of 77 percent. When all licensed psychiatric beds were included, the number of beds rose to 114 beds per 100,000 population with an occupancy of 68 percent.

Blocked Beds Affect Occupancy. Though blocked beds are one of the major factors affecting occupancy, they are rarely included in statistics collected to analyze bed usage (Hall and Bytheway, 1982). A literature review done by Hall and Bytheway (1982) found "at least 40 percent of all patients who no longer needed acute care were causing 'blockages' because of the lack of other 'stages' within a system of progressive care". The beds were blocked mainly by the elderly. A typical bed blocker was female, over 75, living alone or with one relative, who had a fractured femur, head injury, or other trauma. In part, blocked beds resulted from hospital staff who were reluctant to release a patient to what the staff considered to be inadequate home care.

What is the effect of elderly patients on bed management? One committee found "over 65s" accounted for only 5 percent of admissions, yet were 28 percent of stays over 30 days ("Blocked Beds", 1980:1013). In defense of the elderly, a study by Seymour and Pringle (1982:1923) found the elderly did not block beds as much as traditionally found. In fact, only 1 out of 10 patients who was 65 or over, stayed in the hospital 31 days, and less than one percent became bed blockers. Salter (1982:22), a Canadian researcher, also studied the elderly. He found that while 58 percent of patients over 75 were blocking beds, 50 percent of those under 75 were also blocking beds. This did not mean beds were blocked for long periods of time, but up to 58 percent of all patients blocked beds for some period of time, whether an hour or a week.

Dealing With Census Fluctuations. When excess rooms were a problem, some hospitals took the extra rooms and organized a short stay ward that opened during patient overloads (Wimpsett, 1983:28). A 12-bed ward was used in one hospital. The ward opened for 11 weeks. During that time 80 percent of adult medical occupancy was maintained 66.6 percent of the time, and an 85 percent occupancy rate was maintained 45 percent of the time.

MacStravic (1982) says there should be beds available for long-term care but they should be in places such as nursing homes.

Davies, Cliff, and Waters (1981) surveyed five-day wards. These wards exist to serve patients whose stay will be short and can be planned. The results indicated five-day wards were used by many specialty wards as well as mixed wards and the number of beds varied from 12 to 32. Occupancy and throughput rates worked best in hospitals were there was supporting staff and worked poorly in hospitals with low staffing levels. Two reasons to use a five-day ward are (1) it can be an additional resource to reduce waiting lists for specific procedures and (2) if weekends and holidays pose staffing problems, a five-day ward can reduce the cost and difficulty of running traditional wards.

One way to deal with census fluctuations is to smooth out the surgery schedule (MacStravic, 1981:347). Changing to a six or seven day surgical schedule would eliminate program and staffing drop off on weekends and holidays. A hospital might also construct 100 percent private rooms thus relieving constraints on mixing male and female, smokers and nonsmokers, patients with or without communicable diseases, and adults and children. Pooling of beds into non-specialty wards can also help increase efficiency. This would give greater latitude of choice to schedulers and help keep more beds occupied.

<u>New Inpatient Technologies</u>. There are three new types of administrative technologies. These are Admission Scheduling (AS) Systems, Outpatient Surgery (OPS) Programs, and Preadmission

Testing (PAT) Programs (Martin et al., April 1985:63). An AS system will achieve higher occupancy levels and reduce the variability of those levels. An OPS program can reduce the number of inpatient admissions by performing more outpatient surgery. A PAT program can generate timely knowledge of test results and speed up diagnosis thus reducing the length of patient stays and eliminate admissions that are inappropriate on the basis of preadmission test results. PAT programs have reduced average lengths of stay by as much as two days depending on occupancy rate, type of patient admission (medical or surgery), and patient travel distance.

Martin, Wellman, Whipple, Dahlstrom, Becker, and Nash (Fall 1985:324 1985) studied eight hospitals and found implementing a system that included all three of the above administrative technologies resulted in the following benefits.

1. Acute care bed needs were reduced between 4 and 22 percent of total bed allocations.
2. Use of a single year's data are sufficient to determine the effect of the total system.
3. Admission scheduling showed the greatest potential for reducing bed need. Approximately 3 to 20 percent or 6 to 188 of the existing beds were projected as unnecessary in the eight hospitals studied.
4. Anywhere from 0.7 to 8.6 percent of inpatient surgery could be done on an outpatient basis.
5. Bed reduction due to Outpatient Surgery is a function of

(1) physician acceptance, (2) the maximum length of stay (LOS) allowed for previous inpatients to qualify as OPS eligible and (3) the patient travel distance.

6. Implementing Preadmissions Testing reduced bed need anywhere from 0.11 to to 6.15 percent of existing capacity, with an average of 13 beds in the eight study hospitals.

7. Bed reduction due to PAT is a function of the LOS reduction and the type of patient in the program.

8. The potential of OPS and PAT to reduce bed need is greater in community hospitals than in research/teaching hospitals.

Hancock and Walter (1986) found linking admissions and operating room (OR) scheduling resulted in major savings, up to $2,177,280 a year for a 500 bed hospital. To achieve such dramatic cost savings, a 70 percent utilization rate of the OR is necessary. A computer system was also necessary to process procedure times and variances in the OR schedule, calculate start times for procedures with high probability, print schedules on demand, enable efficient scheduling by phone, and update procedure times and variances by procedure and physician. For hospitals with 16 or fewer OR rooms, a microcomputer configuration could run the system.

A computer could also be helpful in the scheduling process. A computer-aided scheduling system might use a normative methodology rather than demand-based methodologies (Martin, Wellman, Whipple, Dahlstrom, Becker, and Nash, Fall 1985:324). A normative methodology can predict changes in utilization and can accept long-range plans for reducing use rates. Since the system depends on a database, a normative based methodology can tailor use rates in the model.

Many new technologies can be used to improve efficiency. An important point however, is that to improve efficiency, admissions must be scheduled systematically and medical staff must be willing to give up some control over the timing of their admissions (MacStravic, 1981).

<u>Models</u>. Models are simply abstractions of systems. Models can be physical, mathematical, or graphic (Cobbin, 1987:5). A computer simulation is a type of model (See Figure 2). Regarding bed management, Hancock et al. said most models can not be used because they are based on faulty assumptions, and neither describe nor forecast the complex operation of an admissions system (Hancock et al., 1978:65).

Many models use a Poisson approximation that is not representative of admission scheduling systems. Hancock et al. also pointed out that despite its non-applicability, the Poisson assumption for hospital census was first used in the 1940s and is used worldwide now. A common procedure, when using a Poisson assumption, is to allow 2.06 standard deviations to correspond to the 98 percentage point, of the normal approximation to the Poisson distribution. When used to predict bed capacity, the Poisson assumption is stated in the following formula.

$$BC = AC + 2.06 \text{ std} \sqrt{AC}$$

Where
BC = required bed capacity
AC = average census or the average number of patients in a year
std = standard deviation

(Hancock et al., 1978:65)

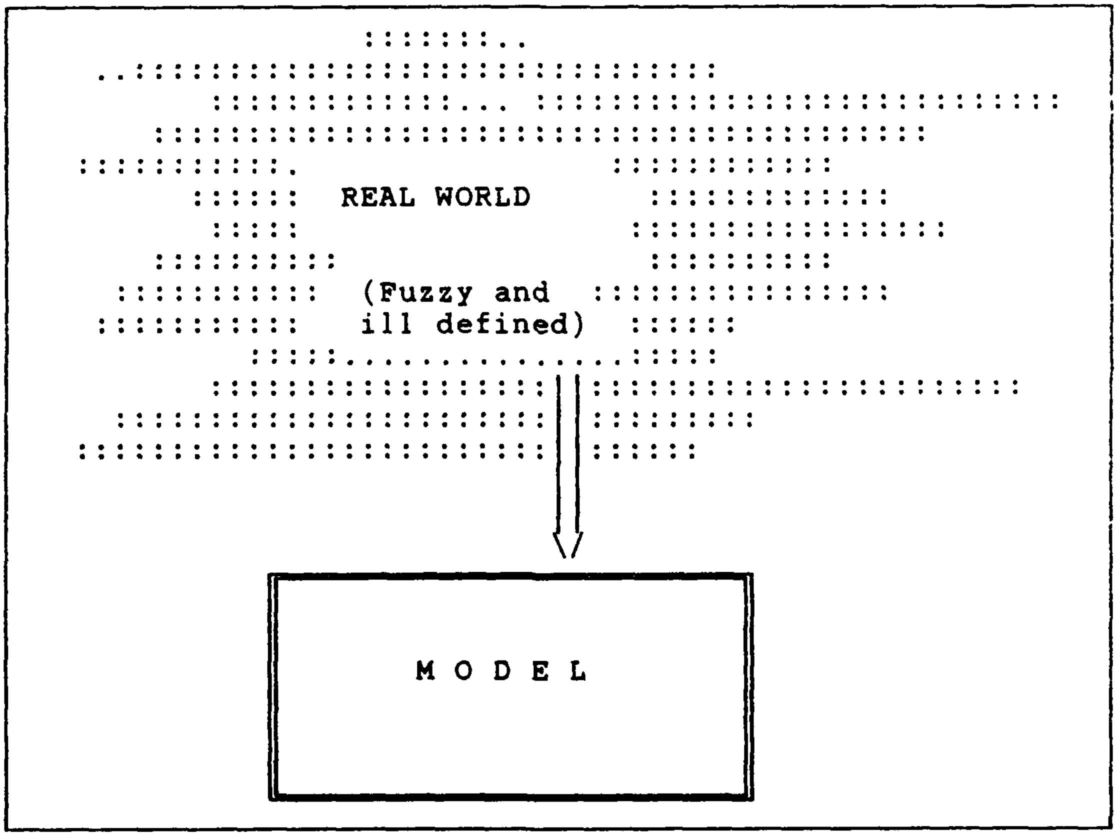


FIGURE 2: A CONCEPTUAL VIEW OF MODELING (Cobbin, 1988)

While the formula does describe the mean performance of individual hospitals, many hospitals operate at greater occupancies than the Poisson assumption predicts. The Poisson approximation allows too many beds. Models based on the Poisson approximation do not accurately model the effect an admissions scheduling systems has on hospital census (Strande 1978:250).

One model cited many times in literature is the Admission Scheduling and Control System (ASCS) developed by Hancock et al. at the University of Michigan. Hancock et al. designed a simulation based model that went beyond a Poisson assumption and predicted higher occupancy rates. Hancock et al. used a simulation to show a hospital with 300 beds can operate in excess of 97 percent occupancy. This finding is opposed to the 85 percent rule many hospitals currently use.

The Hancock model used three types of admissions: Emergency, Scheduled, and call-in patients. The researchers found using call-in categories to reduce the average census depended on a patient's willingness to be on a waiting list (Martin et al., April, 1985:65). Willingness to be on a waiting list depended on the distance between the patient and the hospital as well as the patient's age, and relative physical condition.

Hancock et al. (1978) created a simulation to model an admissions and scheduling control system. Their results showed the overall occupancy of the hospital rose 3.5 percent and the day census stabilized into a predictable pattern. The system eliminated the need for top management to be involved in the admission process and allowed staff to manage admissions rather than respond to them.

Ik-Whan Kwon, Eickenhorst, and Adams (1980) also developed a forecasting model they believe can be used in any hospital. Ik-Whan Kwon et al. gave a step-by-step approach to building a forecasting model. They evaluated two models and found daily schedules needed to be carefully monitored for reliable results. They cautioned the validity of any regression model depends on inputs as well as changes in the social variables.

The literature review was useful in gaining insight into the factors which influence hospital bed management. The review showed WPMC, not unlike the rest of the hospital industry, has had an historical problem with bed management. Although many studies have been conducted in the area, solutions to the bed management problem continue to elude researchers.

III. Methodology

Overview

This chapter outlines the approach used to answer the research questions identified in Chapter I. The research blueprint used in this investigation incorporated exploratory interviews in person and by telephone, a four page written questionnaire, an analysis of the hospital database and records, and a simulation of key elements of the admissions and dispositions process. The specific methodology is discussed in detail as it relates to each research question.

To gain information for the first two research questions, the survey method was used. According to Emory (1985:202-220), a survey strategy must consider whether the type of communication mode should be personal interview, mail, or telephone; whether the process should be structured or unstructured; and whether or not to disguise the objective of the research.

When constructing questions, a researcher should ensure each question is necessary, is in proper scope, is answerable, includes clarity and proper wording, and avoids biased wording or assumptions (Emory, 1985:207, 208). Dillman (1978) discusses wording problems. When writing questions, a researcher must ensure the wording will be uniformly understood, does not contain abbreviations or unconventional phrases, and is not vague, or objectionable. The question must also be technically accurate and allow for answers that are mutually exclusive.

Investigative Question One

How does the current admissions and dispositions process operate at Wright-Patterson Medical Center?

This question was important because understanding the process is the first step toward solving the problem. Two sources were used to answer this question: knowledgeable individuals and hospital documents. Individuals were questioned in personal or by telephone interviews, and internal memorandum and documents were received mainly from those knowledgeable individuals.

Knowledgeable Individuals. One source of information was individuals who were familiar with aspects of the admissions and dispositions process. Personal interviews were used because face-to-face, two-way conversation is an excellent data collection method (Emory, 1985). As discussed in Chapter I, personal interviews can secure depth and detail that exceeds information secured from telephone and mail surveys. Also, there is more control of the situation. Selltzer, Johoda, Deutsch, and Cook, (1959:238-240) discuss advantages of interviews. Particular to this study, interviews yield a better sample of the general population, and people are willing to cooperate when all they have to do is talk.

There are disadvantages as well. One disadvantage is it is possible to influence the response of the interviewee by how the question is stated. Tone of voice, inflection, or question wording can affect meaning. Another disadvantage is the physical surroundings (such as lighting or privacy) of interviews are all different and could affect respondents differently. Even nonverbal communication can influence respondent's. A respondents perception of the interviewer could be negative or positive and the respondent's answers reflect that bias.

To have a successful interview, the respondent must understand his role and be motivated to cooperate. The respondent must also feel the experience is pleasant and satisfying, believe the survey is important, and have all mental reservations settled (Emory, 1985).

Hospital Documents. Another source of information was hospital documents. These included memorandums for records, staff summary sheets, working papers, and various hospital reports. The advantage of this type of information was it could not be biased by the researcher. Still, the researcher must be careful to only report what the documents provide. There could be a tendency to infer beyond the documents.

Investigative Question Two

Do hospital administrators think there is a bed management problem, and if so, what factors do they think affect bed availability?

The answer to this question came from a four page, self-administered, questionnaire given to hospital personnel involved in the bed management process (See Appendix I).

Population. For the purpose of this research, the population who received the questionnaire was made up of the professional staff at Wright-Patterson Medical Center who affected or were affected by the bed management process. This group was chosen because they were easily identifiable through a professional staff list. Also, the professional staff population covered a wide range of specialties and therefore had a wide range of views. Finally, this group was the most likely to be in a position to see problems and suggest changes. A complete census was conducted of the 87 staff members making up the desired population.

Format. After the population was chosen, the questionnaire was written. A research questionnaire typically asks questions that address behavior as well as measure knowledge (Sudman and Bradburn, 1982). However the purpose of this research was not to measure attitudes, but simply to gather information about a specific problem. Therefore, only questions dealing with the specific topic of bed management were asked.

A questionnaire written by Dr. Freda F. Stohrer (1989) of the Air Force Institute of Technology was used as a starting point for writing the bed management questionnaire. Her questionnaire on "Survey of on-the-job writing skills" closely paralleled the needs of this study. Many of her demographic questions were used verbatim. The format of the questionnaire was also followed, with the exception that ranking questions were not asked. Where her questions specialized on opinions about writing, the bed management questionnaire specialized in possible bed management problems.

The bed management questionnaire consisted of three sections. Section one included demographic questions such as hospital position, clinical association and time spent at WPMC. Section two listed possible causes of the bed management problem gleaned from interviews and literature. These possible causes were placed on a five-point Likert scale ranging from strongly disagree to strongly agree. Section three consisted of one open-ended question to allow the respondent to reply as needed.

Pilot Questionnaire. A pilot questionnaire was tested on one civilian, two Air Force Institute of Technology professors, and two hospital staff members. Changes in vocabulary were made at their suggestion and then the questionnaire was sent out to 12 members of the desired population for a final evaluation. These 12 members were selected because they were either part of the WPMC's Bed Management Progress Action Team (PAT) or one of the clinical service's bed coordinators. They received an identical package as the rest of the population except a letter was included telling them of their pilot test selection and requesting a quick response (Appendix I).

Final Questionnaire. Following an analysis of the initial returns, minor changes were made. The final questionnaire was sent out to the remaining 72 staff members in May 1989. The questionnaire included a cover letter signed by Colonel Tuttle, Director of Process Quality Review, Wright-Patterson Medical

Center. The cover letter stressed voluntary cooperation as well as anonymity. It instructed the respondent to return the completed questionnaire to the hospital Admissions Office within 10 working days. The procedure was designed to be "short, easy to fill out, simple to return, sponsored by a group with prestige, and presented in a context that motivates the respondent to cooperate" (Selltzer et al., 1959:238-240).

Questionnaire Analysis. After collection, the results were analyzed for descriptive information. Frequency and histograms were created from the responses. The results were considered interval data for the purpose of using parametric statistics. A one way analysis of variance was computed on three demographic variables for the purpose of using an F statistic. If a difference was found, a Student-Newman-Keul's procedure was performed to determine which groups were different. The goal was to find trend information that would fill gaps of knowledge about the bed management issue that personal interviews had missed. This information became foundational in the construction of the simulation.

Reliability Check. A reliability check with "Statistical Program for the Social Sciences" (SPSS) software was considered on non-demographic portions of the questionnaire. During the consideration, Dr. Bob Steel, Organizational Researcher at the Air Force Institute of Technology, asked how many different areas the questionnaire addressed (1989). The 26 questions used to determine bed management problems could conceivably measure one area (bed management), or several areas (supply vs demand variables), or 26 individual areas. After the discussion with Dr. Steel, the idea of reliability was discarded as inappropriate. Reliability requires at least two questions that measure the same variable. Since the questionnaire was designed to be short, only one question was written to measure each potential problem area of bed management. Therefore, a reliability check with SPSS was not accomplished.

PAT Briefing. The results of the questionnaire were briefed to the WPMC Bed Management Process Action Team (PAT) on 20 June 89. Only one of the team members questioned the validity of the results. He argued that doctors were never asked directly if they perceived bed management to be a problem. Therefore, he thought the results might be biased. He contended that the researcher may have assumed a problem when there really was not one.

The concerned PAT member received an opportunity to state his concerns much earlier as a part of the 12 member pilot test group that received the questionnaire in May of 1989. He was asked to critique the questionnaire prior to its being sent out. Neither he nor any other member of the pilot test group had any major criticisms of the questionnaire at that time.

Nevertheless, directly asking doctors if bed management was a problem was considered during the writing of the questionnaire. The idea was discussed and discarded for several reasons.

1) Bed management was clearly identified as a problem through interviews with six hospital personnel involved with bed management.

2) Hospital records showed bed management to have been a problem for years.

3) The literature search clearly identified bed management as an industry-wide problem.

4) The fact the Bed Management Process Action Team was created in late 1988 to consider ways to deal with the problem of bed management, infers a problem already exists.

5) Even though the question, "Do you think bed management is a problem?" was not explicitly asked on the questionnaire, the question was implied. Each of the 26 specific questions about bed management gave the respondent the opportunity to agree or disagree that a particular area made bed management more difficult. Simply by selecting anywhere between neutral and strongly disagree, a respondent could indicate he did not consider bed management a problem. By continuously marking neutral or less, he could indicate overall bed management was not a problem. In fact, at least one respondent did not believe bed management was a problem. He marked all factors as neutral. Note that the major purpose of the questionnaire was to validate the bed management problem, and to identify causes of the bed management problem.

6) The questionnaire was validated as discussed earlier in this chapter. One of those validation steps was to allow the PAT

to evaluate the instrument before being sent out. PAT members comments were minimal, and the questionnaire was judged sound.

7) The questionnaire results clearly show there is a problem. Twenty two out of twenty six factors were ranked higher than a neutral 3.00.

A second concern raised by the team during the briefing was over the word "ratio" in question 14 of the questionnaire. Question 14 was ranked highest by the respondents as a factor contributing to difficult bed management. Question 14 reads, "The bed management process is made more difficult, in part, by the staff to bed ratio limiting the number of available beds." The team members questioned whether respondents meant number of personnel overall (i.e., not enough workers to support more beds) or the number per bed (i.e., not enough workers per bed). Some team members noted that if beds were reduced, the ratio of staff to beds would increase. However, the statement clearly addressed the need for more staff overall in order to support more beds. Furthermore, respondent's comments confirm they understood the intent of the question. Note the respondent's comments to the open ended question in Appendix J. Not a single comment deals with the number of personnel per bed, but many deal with the number of staff in the hospital or ward and how that affects overall patient care.

Investigative Question Three

Can an accurate simulation be created that will give

new insight into the bed management process?

a. What is the profile of a typical patient?

b. What are the arrival sources?

c. Is there a pattern of arrivals by day of week?

d. Is there a pattern of arrivals by week of year?

e. Is there a pattern of arrivals by month of year?

f. What is the average length of stay of patients by clinical service?

A simulation was chosen as the methodology for this research because a simulation study forces the researcher to understand the process (Cobbin, 1988), and is useful in analyzing and modifying complex systems. The real system was too complex to be modeled mathematically, making a simulation a better choice of methodology (Cook & Russell, 1985:522). In addition, the graphical presentation of a simulation ties all the information together into a visual presentation that communicates the problem to the manager. This could stimulate the hospital staff to become more involved in the problem solution (Dumas, 1985:61). However, the major reason for choosing a simulation was to allow experimentation. In a simulation, variables can be held constant while others are changed much easier than in a real system.

Some advantages of a simulation are: complex phenomena can be dealt with in a scientific way, simulation permits experimentation without actually changing the system, simulation allows the management scientist to gain insight into the system, and simulation allows for the compression of real time. A year's worth of information might be compressed into an hour, depending on the complexity of the simulation.

Once the need for a simulation was determined, a strategy was outlined. The simulation strategy used for this thesis was based on Cobbin's ten steps of the modeling process (Figure 3). Cobbin made an important point about the modeling process: the process is iterative. That is, there is a need to constantly move back and forth between the steps to refine the simulation. The rest of this chapter will be organized using the ten steps of the modeling process.

Problem Formulation

The first two research questions were used to formulate a problem statement for the simulation research. The problem was identified by patients who complained about waiting for beds (Tuttle, 1989), staff interviews, and the staff questionnaire. While the problem appeared to be a lack of beds, the core problem apparently was a lack of customer service identified by past performance. Patients in the past had been turned away from the hospital even though scheduled, and even patients who were admitted often waited for beds. A possible solution might be to add beds. Written as a problem statement, the problem read: "What can be done to improve customer service for inpatients?" One answer, and the one used in this simulation, was to reduce waiting time for patients by re-distributing or adding beds to clinical services until patients waited a minimal amount of time.

Note that adding beds reduces occupancy levels. However, improved occupancy was not the measure of success for this simulation.

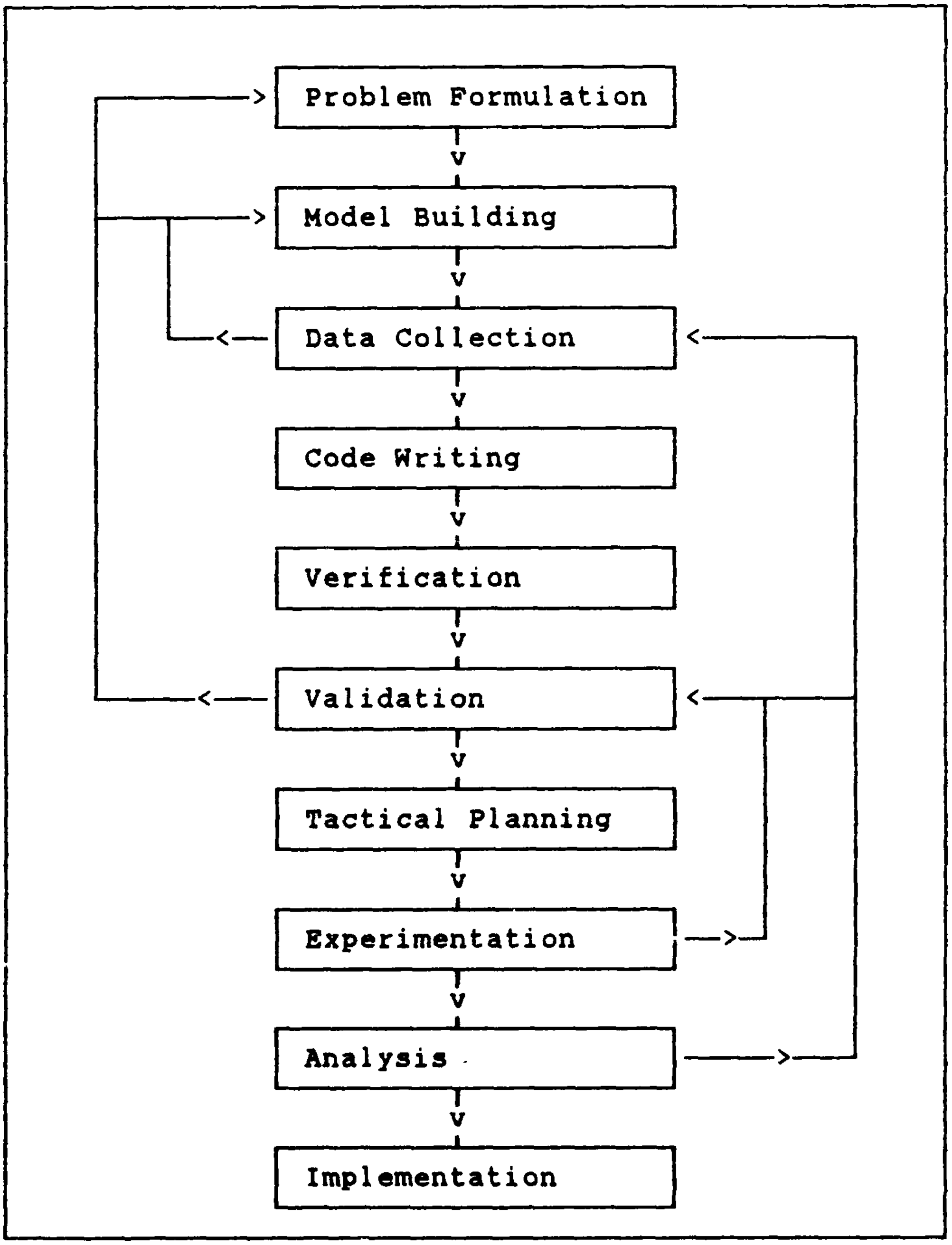


FIGURE 3: THE MODELING PROCESS (Cobbin, 1988)

Model Building

Before beginning to build a simulation model, an understanding of the process is necessary. Knoop's diagram (Figure 1 in Chapter 2) was used as a beginning. The diagram was later refined by Captain Meccia (Figure 6 in Chapter IV). This graphical model served a basis upon which to begin the simulation model.

Assumptions. Before and during data collection, many assumptions had to be made. The ones listed here apply to all steps of the modeling process. They also serve as a foundation for understanding the simulation, and to demonstrate the iterative nature of the modeling process. Strande's (1978) study was referenced in developing assumptions for this model. The following assumptions apply:

1. Without an admissions scheduling system, patients who could be scheduled arrive randomly.

2. Patients who could be scheduled, but could not gain an admission, arrive through the Emergency Room.

3. Given the proper number of beds, admissions scheduling and utilization reviews have the potential of eliminating the problem.

4. Even with hospital construction, the 1988 data reflect normal patient arrivals. Two inpatient clinical specialties, Pediatrics and Orthopedics, were known to have closed down for approximately three months, or 25 percent of the year. To "correct" for this reduced demand, the current supply of beds for

each of those clinical specialties was also reduced by 25 percent and the arrivals averaged as if for a full year.

5. Information on the "Inbound/Outbound Aeromedical Evacuation Aircraft" form was correct (AFLC Form 6400, 1987). Furthermore, patients on the Aero Evac list not labeled as outpatients were assumed to be inpatients.

6. Children two and under slept in cribs, while those over two slept in adult beds with guard rails. Therefore, two and under were removed from the arrival process since they did not affect adult bed management.

7. Several clinical services used the ambulatory self care ward. Those clinical services received a portion of the ambulatory self care beds in proportion to the using clinical specialty's number of total beds.

8. Surgery and Medicine ICU beds were used only by their respective clinical specialties. Thus six ICU beds were added to Surgery's total available beds, and six ICU beds were added to Medicine's total available beds.

9. Since the number of males in the year equalled 52 percent, and the number of females equalled 48 percent, it was assumed there was little, if any, conflict caused by gender. Therefore, a same sex patient could easily be found to share rooms and beds would not be blocked from lack of a same sex patient.

10. When using the database to determine the historical length of stay, a patient's length of stay began at 1200 on the

day he checked in and terminated at 1200 on the day he checked out of the hospital.

11. Patients who checked in and out on the same day had a length of stay of one day.

12. Bed turnover took an hour. Drake (1989) says most often it takes a half an hour to an hour from the time a patient leaves until the bed is ready for a new patient. Meccia (1989) confirms that the time between when a departing patient has vacated the bed, and the time a waiting patient could go to the bed is a half an hour to an hour on average. This assumes patients did not all leave at the same time.

Data Collection

When developing a simulation, having reliable data are extremely important. Tradeoffs must be made between accuracy and availability. Database information on patients was used to determine patient arrival rates, bed allocations, and length of stays. For this simulation, data were acquired by retrieving information from the hospital database and from personal interviews. The database provided the information needed to build the simulation. Personal interviews with hospital experts were used to determine the process flow of patients into, through, and out of the hospital.

Hospital Database. It was recognized information from the hospital database might not be complete or accurate. The accuracy depended mainly on the individuals who originally input the data into the computer. Still, the large amount of database information gathered by the normal admissions process promised to give unbiased information about the bed management process.

The hospital database provided detailed information on all admissions. There was an intense attempt to transfer the entire database in an electronic form to a mainframe computer for statistical analysis. However, due to software propriety, the information was not accessible in such a manner. To avoid an enormous data entry task (e.g. 7250 records with 35 fields), it was necessary to sample the data.

Two Data Lists. Two data lists were generated by the WPMC computer personnel and used for different purposes. The data list used for the sample population, "Listl", was also used to determine arrival rates. This was done by simple counting and sorting procedures. From this total population, arrival rates and total patient arrivals for Emergency, Air Evac and Scheduled admissions were determined. Listl consisted of all hospital patients admitted during the year 1988. It contained specific data including dates of admission and disposition, ward of stay, and governing clinical specialty. In addition, demographics such as age and sex were gathered. The information was printed in a hard copy and then manually input into a computer for analysis.

Originally Listl gave a population of 9443 inpatients admitted during the year 1988. Of that list, 801 names were eliminated because those patients had been assigned to home quarters and would not use hospital beds. A small number of these did enter the hospital as inpatients and were therefore retained. Cancellations were another large group of names deleted. They represented another 657 entries. Reasons were not given for the cancellations. A third group of names deleted were "same day surgery unit". They totaled 442 names. Those patients operated as outpatients and did not usually affect inpatient bed usage. Children two and younger on the day of admission totaled 253. They were removed from the list because it was assumed they would use a crib, while those over two would sleep in a bed with guard rails. A discussion with Meccia (1989) validated this assumption. Finally, 20 Emergency Room deaths and 20 miscellaneous names were removed from the list. The total population remaining was 7250 patients.

Once the database was understood better, WPMC computer personnel were asked to generate a second, complete and specific census of inpatients by clinical specialty. The second data list, "List2", showed 6995 inpatients had arrived in 1988 and gave information only on the clinical specialty and length of stay those patients had experienced, and a frequency count by clinic, of length of stay of patients. This computer printout showed the total patient population to be 6995, or about 96.5 percent of the 7250 mentioned in List1.

Each database--although describing virtually the same patients--had some strengths over the other. List1, with 7250 patients included many demographic variables and was used to describe the population and determine the number of Emergencies, Aero Evac, and Scheduled patients as well as an evaluation of typical patients. List2, with 6995 patients, was designed specifically to determine the number of arrivals, exactly what percentage of patients each clinical specialty had received, and what an average length of stay was for each clinical specialty. The numerical difference between the two totals was 255 records or 3.5 percent.

Sample Population.

After List1 was reduced to inpatients only, a random sampling design was used to select a representative group. The sample size was chosen based on a confidence/reliability of 95 percent ± 5 percent according to the following formula.

$$\text{Sample size:} \quad n = \frac{N\sigma^2}{(N-1)\,D + \sigma^2}$$

Where n = sample size

N = population size

$D = \frac{B^2}{4}$

B = the bound of error of estimation

(Scheaffer, Mendenhall, and Ott, 1979:43)

Based on a random sample of 50 used to estimate the standard deviation, an N = 7250, and a desired patient stay estimated within a bound of ± two days, an initial sample size of 203 was determined sufficient to describe the entire patient population. After randomly selecting the sample of 203 by using a random number generator, a new standard deviation was computed based on the new, and larger sample size. The updated formula suggested a sample size of 732 would yield 95 percent reliability level. After two outliers of 171 and 174 days were removed, the sample size formula was again computed using a new standard deviation. This time a sample size of 195 was determined sufficient. The eight extra observations already obtained were kept, further increasing accuracy. This sample was used to estimate demographics of a typical patient.

Probabilities. Once patient information was gathered, it was analyzed to determine probabilities to be used in the simulation. Probabilities allow a simulation to generate information from random number generators without needing specific data. The relative frequency concept of probability was used because it gives a practical interpretation of the probability for most events of interest (Ott, 1988). The relative frequency concept of probability is an empirical approach. If an experiment is repeated often such that an event occurs 25 percent of the time, then .25 would approximate the probability of the event.

Kerlinger (1964:129) discusses the three fundamental properties of probabilities. He discusses how to compute probabilities by determining the sample space, sample points and events. Events can be seen as simple events or compound events. Conditional probabilities must also be considered if events are not independent.

Descriptive Statistics. The sample data were analyzed to determine frequency according to age, sex, and locality. Ott

(1988) gives guidance on constructing class intervals. He mentions the importance of eliminating any ambiguity in placing measurements into the class intervals.

All data were also analyzed using descriptive statistics (Ott, 1988). Numerical and graphical techniques were used. The data were analyzed for measures of central tendency as well as measures of variability. These measures were necessary to specify distribution parameters for the simulation. Numbers dealing with the mean were necessary to set arrival rates of patients and the average length of patient stay per clinical specialty. The standard deviation was also required whenever a normal distribution was used. Other measures: mode, median, and range were necessary to gain a complete understanding of the impact of the variables of intent on the admissions and dispositions system.

Distributions. Frequency tables were constructed on the number of patient arrivals and average length of patient stay per clinical specialty. The frequency was plotted as a histogram to estimate the type of distribution. After the arrival data were compiled, they were tested by using the Chi Square test (Shannon, 1975) or the Shapiro-Francia statistic (NH Analytical Software, 1988).

One way data were analyzed for distributions was by day of the week. Normality was tested with the Wilk-Shapiro Rankit Plots test of Statistix(tm) statistical software package. It generated "an approximate Wilk-Shapiro normality statistic, the

Shapiro-Francia statistic." (NH Analytical Software, 1988). The Wilk-Shapiro Rankit Plot Test, plots residuals against their expected values under normality and is called a normal probability plot (Neter, Wasserman, Kutner, 1985:118). If a sample is normal then a plot should result in a straight line. A large value in the Wilk-Shapiro statistic, which is the correlation coefficient, means the more likelihood of normality (Statistix, 1988:8 4). A value of .90 or more is indicative of normality (Neter, et al., 1985:120). Chapter IV discusses the results of those tests.

This arrival information was used to create seven daily distributions that uniquely modeled the number of patients that normally arrived for a particular day of the week. The daily distribution accounted for daily variations. Table 19 in Chapter IV shows the average daily mean used for all arrival sources.

The data were further analyzed by week of year and month of the year to determine other yearly trends. A significant dip during late spring and early summer suggested a trend. However, further investigation revealed the hospital had closed two of their wards during that period. No other trends were obvious. The end result was an approximate number of patients were created that modeled arrivals for the entire year by day of week. Week of year and month of year were not usable in the simulation. A week would require unnecessary computer coding and a month would not account for variation by day of week.

Code Writing

With the data in hand, the simulation model was constructed (Appendix L). Simple_1(tm) simulation software was used to write the code. Simple_1(tm) is a MS-DOS(tm) based program for IBM(tm) computers and true compatibles. Although the program is limited to the RAM memory of the microcomputer, its ability to be run on a microcomputer allows its use in field settings.

Two Simulations. After the code was written, two simulation models were created. The first simulation (Sim1), was slightly different from the second simulation (Sim2). Sim1 modeled the hospital as it currently operates. The simulation accounted for variability from all three arrival sources: Emergency, Scheduled, and Aero Evac. Arrivals were modeled, as a group, for each day of the week, by using a normal distribution.

Sim1. Though Emergency arrivals were random, and Aero Evac arrivals were usually Monday, Wednesday, and Friday, the number from those sources were not significant enough to demand a separate arrival process. On the other hand, Scheduled arrivals accounted for 79 percent of all arrivals. When all arrivals were considered, regardless of the arrival process, scheduled arrivals absorbed the randomness of Emergency and Aero Evac patients and allowed the entire group to be modeled as if from one source with a normal distribution. This simplification of arrivals reduced simulation run times while still accurately modeling the number of arrivals.

The Wilk-Shapiro Rankit Plot test was used to determine if the distribution was normal (Appendix F). All plots from the distribution data were straight and the Wilk-Shapiro approximate statistic was 95 percent or greater for all cases indicating a strong case for normality.

Sim2. The second simulation attempted to model a hospital that had a constant Scheduled arrival rate equal to the WPMC current day of the week average. For that series of simulations, the average Scheduled patient arrival rate was set constant, according to the day of the week. The unscheduled arrivals (Emergency and Aero Evac) were combined and modeled by a Poisson distribution (Appendix G). The combined arrival rates for unscheduled arrivals were evaluated with a Chi Square test. All tests failed to reject the null hypothesis of a Poisson distribution.

If arrival distributions are Poisson, as in Sim2, then interarrival times are distributed exponentially (Budnick, Mcleavey, and Mojena, 1988:770). While a Poisson distribution models number of events per unit of time, an exponential distribution models the interarrival rate and assumes patients arrive randomly throughout the time period according to an exponential distribution. In this case, the interarrival interval was known (one day), and it was known most patients typically arrive in the morning. Thus, the interarrival rate did not need to be modeled. The average group size was also known. Instead of a model using an exponential distribution, Sim2 created the patient group with a Poisson distribution and then split the group into individual patient entities.

When the patients were created in the simulation, the number of patients arriving totaled for the year 7069 for Siml and 7226 for Sim2. Since the results fell between the two data listing patient totals of 6995 and 7250, the arrival rate was deemed acceptable.

Create Statements. Seven create statements were used to model the seven days of the week. A test of the number of patients created by the seven create statements was accomplished by isolating the create statements. Siml created 7077 (See Table 1) arrivals over a period of a year, or 101 percent of the expected. The second simulation model created 7225 arrivals or 103 percent of the actual 6995 arrivals. While the daily means fluctuated between 92 percent and 1.08 percent of 1988 arrivals, the overall number of arrivals was very close. The higher arrival rate was allowed in order to be conservative with arrivals.

TABLE 1 : VALIDATION OF CREATE STATEMENTS

Day	Expected Arrivals	Siml Value	% of Expected	Sim2 Value	% of Expected
MON	1423	1399	.98	1476	1.04
TUE	1232	1242	1.01	1221	.99
WED	1267	1203	.95	1275	1.01
THU	1065	1036	.97	1018	.96
FRI	802	740	.92	777	.97
SAT	463	499	1.08	481	1.04
SUN	972	958	.99	977	1.01
TOTAL	6995	7077	1.01	7225	1.03

Sim2 created arrivals differently than Siml. The purpose of Sim2 was to test an "improvement" over the Siml. Sim2's arrival rate was allowed to exceed the Siml'a to ensure low arrival rate in Sim2 did not cause Sim2 to appear better.

Note that while the two simulations did have different arrival rates, they used the same random number generator seeds, and the number that entered the "wards" (Table 2) for the Siml were within two percent. The number that entered the "wards" for Sim2 met or exceeded the expected amount of Siml (except for Mental Health which had five fewer patients).

TABLE 2 : VALIDATION OF BRANCH STATEMENTS

Day	Expected Arrivals	Siml Value	% of Expected	Sim2 Value	% of Expected
CCU	144	143	.99	144	1.00
GYN	503	501	1.00	535	1.06
OB	1170	1156	.99	1189	1.02
ORTHO	655	663	1.01	681	1.04
PED	215	212	.99	240	1.12
MED	1825	1856	1.02	1885	1.03
MH	315	320	1.02	315	1.00
SUR	2168	2218	1.02	2226	1.03

As earlier stated arrivals were modeled by day of week. Each day patients entered the hospital as a group. The group size dependea on the day of the week. After entering the hospital, the group was divided according to type of arrival based on historical percentages. Emergency arrivals received 8 percent of patients, Aero Evac received 13 percent and scheduled arrivals received 79 percent of all patients.

Day Defined. In order to simulate times, a day had to be defined. A hospital day was modeled as an eight hour duty day starting at 0800 and ending 1600. This was logical. At WPMC, most arrivals occur during the morning hours, and departures occur through out the duty day.

As is found in practice, most Scheduled patients arrived during the morning of the duty day they were admitted on. At WPMC Aero Evac patients usually arrive in the morning. Logically the only patients that would not enter the hospital during the duty day were Emergency patients. In 1988, Emergency arrivals averaged 2.31 to 2.75 arrivals per day and arrived during a 24 hour day. It was probable that one third of those unscheduled patients would arrive during the eight hour duty day anyway. Therefore, for the sake of simplicity, the few patients that arrived outside of duty hours, were instead modeled to arrive during the duty day.

Most patients also depart during the duty also. Patients so not check out throughout the 24 hour day. Thus simulating an eight hour day allowed easier control and analysis of both arrivals and departures.

Arrival Time. All patients were modeled to arrive at 0800. This modeling plan is conservative. It allows all patients to arrive early in the day resulting in higher demand for beds than would normally be needed if patient arrivals were spread throughout the duty day. A higher demand would suggest more beds be added to meet demand. The assumption of an eight hour duty day with patients arriving at 0800 made simulation results interpretable to the time of day.

How Long To Wait? By using these assumptions of time, it was possible to determine how long a patient waited for a bed after being in-processed. Patients checked in at 0800 and, except for Emergency patients and critical care unit patients, went through a four hour in-processing period. After that they entered a ward queue until a bed was available. The simulation program kept track of the time patients were in the ward queue. The simulation also showed the longest time any one patient waited for a bed.

One of the purposes of the simulation was to determine what was a reasonable time to wait for a bed, if at all. If a policy of always having a bed ready as soon as needed were adopted, the result would be excess beds and waste. It would be possible for a hospital to add a bed, holding it empty all year, for that one time in the year that one extra patient arrived. The hospital would chase demand and waste capacity. If 10 patients arrived needing 10 beds at 1200, and each were given a bed, and one hour later, at 1300, 10 different patients checked out leaving empty beds, the hospital would need a total of 20 beds for that day; 10 for arriving patients, and 10 for departing patients. Yet, at 1300, 10 beds would stand empty. On the other hand, if those 10 arriving patients were allowed to wait until 1400, or two hours, then they would take the dismissal patient's beds and there would be no bed excess. The goal of a hospital should be to discharge patients before incoming patients have waited an unreasonable amount of time. This will maximize resources and customer service.

A prudent strategy then was to simulate a no later than time patients could wait for beds. Patients arrived at 0800, and in processed until noon. They did not need a bed until noon at the earliest. Their luggage would either remain at home, in their car, or in a storage room A&D supplied. Therefore, a no earlier time limit of 1200 seemed acceptable. On the other extreme, a policy had already been set by Colonel Randolph, Director of Hospital Services, WPMC, that patients waiting for beds past 1600 was unacceptable (Randolph:1987). So a maximum no later than time was already set at 1400. To be conservative and improve customer service, a no later than time of 1512 was selected.

This time of 1512 was selected partly because the simulation gave times in the queue as percentages of days to one decimal point. While the entire simulation could have been coded in time units of hours rather than days, the detail would have increased the simulation run time dramatically. Therefore, day units of time were used.

A time could only be observed precisely to .1 day, or 48 minutes (8 hours times .1 = 48 minutes). A patient that waited for a bed a simulated time of .5 days equated to four hours, or a time of 1600. That waiting time was too close to Randolph's time limit and unacceptable. The next observable time was .4 days and equated to a 3.2 hour wait after 1200, or a time of 1512. A waiting time of Ø was equal to beds being available at 12ØØ or earlier. As a maximum limit then, it was decided no one patient would be made to wait for a bed longer than 3.2 hours, or until 1512.

The critical care unit for cardiology patients qualified as an exception to this rule. Since a wait could result in loss of life, the criteria for the CCU ward was that no patient could wait at all for a bed. The wait time for cardiology patients had to equal Ø.

<u>Patient Priority</u>. Of course, Emergency patients also needed priority. To handle this need for priority, Emergency arrivals, and CCU arrivals went directly to the ward queues without any in-processing. The rest of the patients in-processed for four hours, or until noon. Emergency and CCU patients pre-empted any patient already in the bed queue. It was possible a patient who had been waiting in a queue for several "days", would lose his bed to an Emergency or CCU patient.

<u>Ward Closures</u>. A particular problem that had to be dealt with was hospital ward closures. During late spring, the Pediatric and Orthopedic wards were shut down for three months. Since their annual demand was reduced by 25 percent, the arrivals for those wards was averaged out as if it were the yearly demand and matched against the bed reduction. To make the number of beds comparable to demand, Pediatric and Orthopedic beds were reduced in the simulation by 25 percent and the simulation runs were made based on the reduced level.

Patient Distribution. Of all arrivals (Figure 4), Surgery got 31 percent, Medicine received approximately 26 percent, OB received 17 percent, and 9 percent went to Orthopedics. Another 7 percent of patients went to GYN, 5 percent went to Mental Health, 3 percent went to Pediatrics, and 2 percent went to Critical Care Unit. Each of these wards had a length of stay that was modeled exponentially. After their stay, patients out-processed and after 364 "days" the simulation was finished.

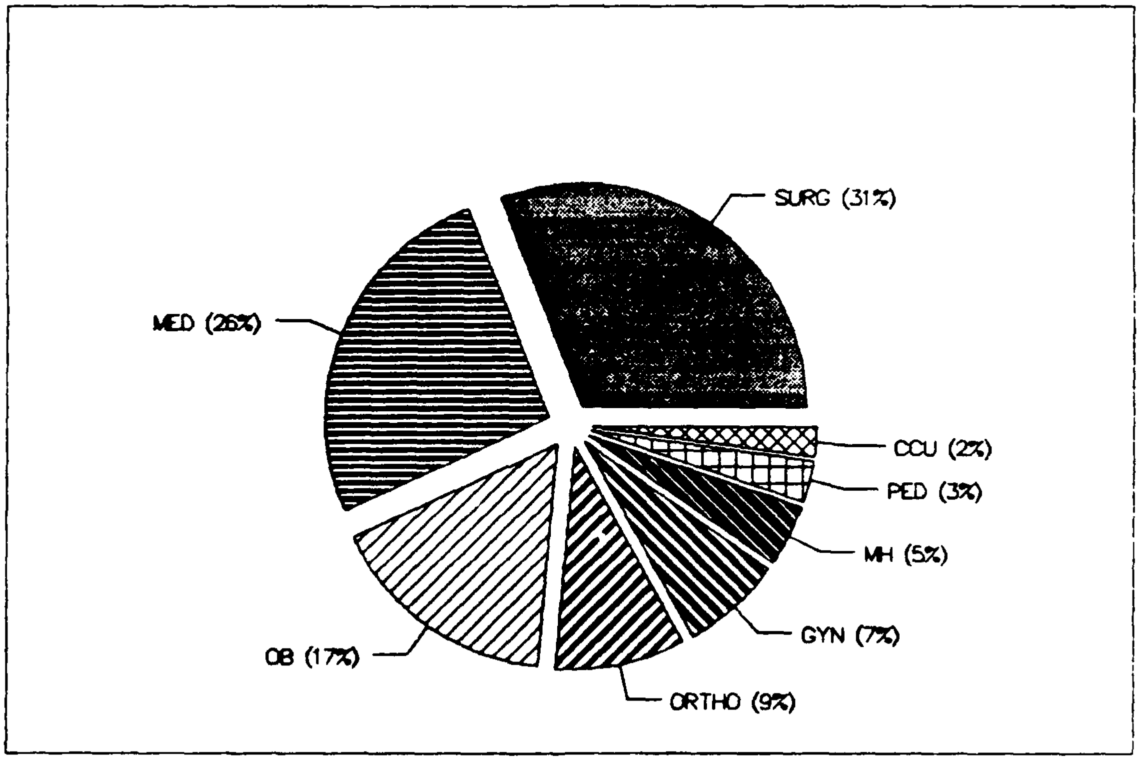


FIGURE 4: CENSUS - ARRIVALS BY CLINICAL SPECIALTY

Length Of Stay. Length of Stay (Figure 5) was computed by taking the departure date and subtracting the arrival date. A problem with this method was if a patient checked in and out on the same day, his length of stay would be zero even though he had blocked a bed. To account for this problem, all zero lengths of stay were rounded up to one day.

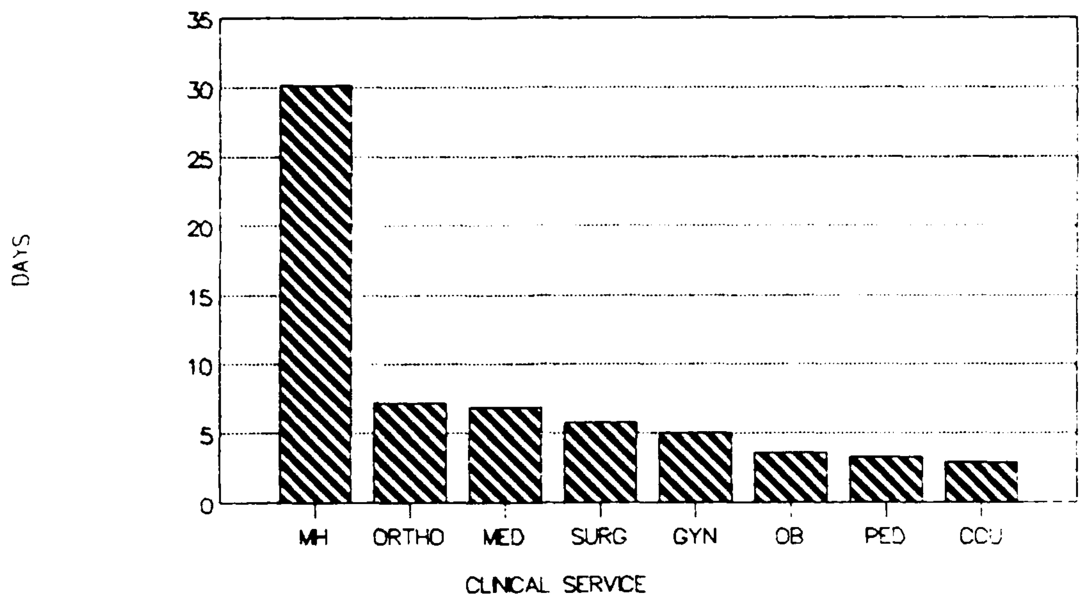


FIGURE 5: CENSUS - LENGTH OF PATIENT STAY

The length of stay was determined by looking at all clinical service specialties and determining the average stay by clinical specialty. Those clinical specialties with one or two patients per year were combined with larger clinics. The end result was seven clinical specialties and one ward were modeled (Table 3).

For modeling purposes, the length of stays were assumed to be exponential. The data were tested using a Chi Square test. All passed, although some classes were quite wide and thus may be suspect. For example, Mental Health seemed just as likely to have two or three patients at 5 days as at 164 days, with a majority of patients (60) having stays that averaged around 29

TABLE 3 : HOW CLINICAL SERVICES WERE MODELED

SRVC CODE	WARD	SERVICE	NUM BEDS	PERCENT ARRIVALS	AVG LOS
AAA,AAB AAC,AAH	CCU	Cardio	7	.0206	2.87
ACA	2S 3W	Gyn	6+4+1(a) = 11	.0720	4.96
ACB	2W	Lab&Del	18	.1675	3.53
AEA,AEB	2N	Ortho	20+1(a) = 16(c)	.0938	7.08
AAA,to AAL	3W 3S 4S	Med	19+17+5 +6(b)+4(a)= 51	.2613	6.82
AFA,AFB		Psych Drugs/ Alchohol	20+32+3(a) = 55	.0451	30.13
ADA	2S	Ped	= 7(c)	.0308	3.24
ABA,to ABK	2S 4S 2N 4W ICU1	Surgery	8+5+11+23 +6(b)+4(a) = 57	.3104	5.77

a) Allocated beds from 4s Ambulatory Care
b) Allocated six ICU1 Beds
c) Reduced 25% due to ward closures

days. The distribution was obviously not uniform, nor was it normal. Only when classes were made 40 days wide would Mental Health length of stays pass a Chi Square test for an exponential distribution.

Special Case: CCU. The one exception to modeling clinical specialties was the Critical Care Unit (CCU). Special consideration was given to the CCU, which was comprised of patients from many different clinical specialties. When determining the length of stay for the CCU, all patients in the CCU were used. If a patient was "assigned" to the CCU, he was not used in the clinical specialty he came from. For example, if a CCU patient was an AAA Internal Medicine patient, he was removed from the AAA list and placed on the CCU list. The CCU is not a clinical specialty, but a ward.

A problem with this procedure of modeling a ward instead of a clinical service, is it does not allow for transfer into other wards. Since the database only gave the entering ward, the information assumed a patient was in the CCU his entire stay. One would expect the determined length of stay in the CCU ward to be higher than actual since the time spent in another ward would instead be average into the CCU length of stay. In 1988 a CCU patient did stay in the hospital for 44 days, and the length of stay was counted against the CCU ward. However, as the simulation results show, the ward experienced low occupancy and excess capacity. In spite of this, it was still necessary to model the CCU ward separately. It would have been a poor practice to penalize the Medicine clinic with the CCU's low occupancy.

Statistics. The model was constructed to keep track of numbers of patients and waiting times. Statistics were kept on arrivals, queue lengths and ward activities. On the overall system, the model tracked occupancy rate, time spent in queues and wards, total number of patients in the system at the time the simulation stopped, and total number of patients that had been processed. Control statistics were established by running both Sim1 and Sim2 under normal operating conditions.

The model was placed into steady state by allowing patients to fill adult beds for 60 "days". This step was important to collect statistics on a hospital already in operation. The period of time between when an organization is in an empty state to when it is in its operating or steady state is called the start up period and should not be used to evaluate the steady state. Cobbin says,

> Statistics collected during simulations can be significantly influenced by the initial start up period, particularly when the model is started up empty and idle in a discrete model. To compensate for this phenomena, it is necessary to be able to run the simulation through a transient period, clear statistical accumulators, and continue the simulation (Cobbin, 1987:7-1).

Some businesses, like a fast food restaurant, begin each day empty and move through a transitory phase into a steady state. A hospital however, does not start its daily operation by opening the doors to customers at 0600, but is always in a steady state. If, during the simulation, a hospital takes 60 days to reach the steady state, it would be incorrect to average the start up figures with the steady state figures. A ward that started out with zero patients would obviously show a lower occupancy.

A start up period of 60 days was deemed sufficient for the hospital to reach a steady state. With approximately 135 patients a week entering a 229 bed hospital, 1154 patients would arrive in 60-days. At the end of the 60 day start up period, patients were left in queues and wards. However, all statistics registers were cleared out and re-started on new, incoming patients whose processing would be affected by patients already in the hospital.

Verification

Verification is the process of checking that the code is error free. The model was verified during the compilation and run phases of Simple_1 (tm). The program itself checks for errors both during the compilation phase and the run phase of model operation. The model was built in stages, compiled and run until error free. When one stage was built and verified, a second stage was added. Many errors passed the compilation phase but had to be resolved during the run phase.

Validation

Validation is very important to the use of the model. Validation ensures the model simulates what it proposes to simulate. It is a reliability check. Seven validation tests were used from Sargent's list of 15 (1987:33, 34). The seven used were: degenerate tests, extreme condition, fixed values, internal validity, traces validity, face validity and animation graphics.

For the first validation test, degenerate tests were performed by isolating the arrival portion of the model. Arrivals were then increased and decreased to ensure the number of entities being created were increasing and decreasing respectfully. Another degenerate test involved increasing the number of beds and verifying lines decreased, occupancy decreased and number in the ward increased.

For the second validation test, extreme condition was used. This was done by testing the model to ensure it could handle unlikely combinations of levels (Sargent:1987). In this case, the arrival rates were generated for 2500 days or about seven years. Problems were corrected and the validation re-run satisfactorily.

The third validation test was a fixed values test. Probabilities were calculated by hand and compared to the computer output. The computer output was also compared to actual historical data with excellent results. For example the simulation's average length of patient stay was compared to the previous computed length of stay. Table's 1 and 2, illustrate the number of patient arrivals for a year in the simulation compared to expected values. Table 4 illustrates the validation of length of stay by comparing expected values to the simulated values.

Internal validity was the fourth validation test used. It was conducted by running the model through multiple runs and comparing the results for logic. There was consistency between the runs.

The fifth validation test was a trace validity test. Patients were traced through the system to ensure the system

TABLE 4 : VALIDATION OF LENGTH OF STAY

Sim Ward	LOS Expected	Sim1 Value	% of Expected	Sim2 Value	% of Expected
CCU	2.87	2.68	.93	2.67	.93
GYN	4.96	4.23	.85	4.17	.84
MED	6.82	6.93	1.02	6.93	1.02
MH	30.13	30.32	1.01	29.94	.99
OB	3.53	3.55	1.01	3.54	1.00
ORTHO	7.08	7.24	1.02	7.19	1.02
PED	3.24	3.04	.94	3.03	.94
SUR	5.77	5.68	.98	5.67	.98

Time = 365 days or 1 year

logic was correct. Problems were corrected and the test repeated until expected outcomes were achieved.

The sixth validation test was face validity. It involved letting people knowledgeable about the process examine the results. Capt Meccia viewed the prototype simulation as well as discussed the theory of the process (Meccia, 1989). The simulation results were also discussed with Colonel McDonald, Chief of Medicine (Mcdonald, 1989). Length of stay, occupancies, as well as number arriving per ward were discussed. Some of his comments were that CCU results seemed low but the rest "sounds correct".

The seventh validation test was animation graphics which gave a visual validation of the model's operation. All arrivals, queues, and wards were modeled graphically by displaying the number in those areas on the computer screen as well as an ASCII character on the screen. This was helpful in debugging as well as visually displaying results.

Tactical Planning

A plan of experimentation was reached with the help of hospital literature, personal interviews, and the hospital staff survey. These sources gave three distinct directions to follow in experimenting with bed management problems: 1) change capacity, 2) change the length of hospital stays, or 3) change admissions. Given the nature of illnesses, reducing the length of hospital stays at WPMC appeared unlikely. However, changing capacity and admissions were both possible. Therefore, the tactical plan called for manipulation capacity and admissions.

Experimentation

The number of total beds used was 229, based on beds available as of 14 June 88. Beds were grouped by clinical service specialty according to the order and numbers presented in Table 3. At the end of 60 "days", the statistical accumulators of the model were cleared, and new statistics were accumulated for 364 more "days" or exactly 52 weeks.

In Sim1, the number of beds were manipulated to answer the question, "How many beds are needed to reduce the waiting time of patients to the predetermined window?" For the design of this experiment, single variables were varied to simplify interpretation of results. Inter action effects were not considered. For example, Medicine beds were changed from 51 to 50 while all other wards kept the same bed allocation and arrivals were created exactly the same. After the change, the simulation was operated under the same conditions as the control run to determine the effect the change had on patient waiting time.

After the run, beds were added or subtracted depending on the simulation results. This process was repeated until the statistics showed the maximum any patient waited for a bed was 3.2 hours. This policy allowed waiting by at least one patient at some time during the year.

Sim2 was conducted to answer the question, "Would bed management be improved if Scheduled patient arrivals were set constant by day of the week mean?" The number of Scheduled patients were set constant according to the historical daily mean and added to Emergency and Aero Evac arrivals that were being created. Beds were again added or reduced until patients waited a maximum of 3.2 hours.

Analysis

Once both Sim1 and Sim2 experiments had been conducted, the results were analyzed. If a flaw in logic became apparent, the iterative nature of the modeling process took hold and the process returned to earlier steps to improve the simulation. When the analysis of the simulation output revealed l[illegible]al and satisfactory results, the results were examined as they related to the research question.

The simulation results were analyzed to determine average occupancy rates using Gilbony's occupancy formula (Gilbony, 1969:515). Occupancy rate is a measure of a hospital's efficiency. Basically, it is the total patient days used for a period divided by the total possible patient days for the same period.

The results of the two simulations were formulated into recommendations that were briefed to the hospital staff. A list of the findings and recommendations are in Chapter IV of this report.

Implementation

According to Cobbin, implementation of a simulation study is the most difficult part of the modeling process (Cobbin, 1988:5-6). He says, since modeling is an abstract representation of the real world, implementation will probably identify errors made in a simulation study and earlier studies. The purpose of a study is to solve a problem. More likely, the study will result in a better understanding of the problem and possible solutions rather than direct specific implementation.

The implementation step was left up to the hospital staff. The research however, attempted to identify potential pitfalls in blindly implementing recommendations from a single study and cautioned the hospital staff to consider all the research in this study as well as in the field.

Summary

Chapter III has presented enough detail that a reader or later research can replicate the results. It covered details about interviews, the questionnaire, and the simulation. Chapter IV will discuss the research results.

IV. Research Findings

This chapter presents the results of this research effort. The investigative questions will be used as a framework for explaining the findings. The results of the questionnaire analysis, interview process, and simulation will be presented sequentially.

Investigative Question One

How does the current admissions and dispositions process operate at Wright-Patterson Medical Center?

This question helped define the bed management simulation by formally documenting the process of admissions and dispositions. Two sources were used to answer this question: knowledgeable individuals and hospital documents. Individuals were questioned in person or during telephone interviews and documents were received from hospital records.

The Process Of Admissions And Dispositions

The availability of beds is a function of policies, set by people, that result in the process. A discussion of the admissions and dispositions process will lay the foundation for understanding the issues that impact bed availability. The following section describes the procedures a typical patient follows to enter the hospital.

Referral. When a patient has a medical problem the patient is referred to a specialized clinic and sees a physician (Meccia, 1989). If the examining doctor determines the patient needs inpatient care, the doctor checks his own and the patient's personal schedules, the operating room schedule (if applicable), and determines if a bed will be available. When a convenient date is found, the patient is scheduled in the clinical specialty's books, but not actually allocated a bed (Meccia, 1989). The date of scheduling may be from one week to several months before the actual admittance date. Determining the date considers neither the scheduling of other clinical specialties nor the actual number of inpatients scheduled for admission.

Preadmit Interview. The patient is given an Air Force form 560 "Authorization and Treatment Statement" and sent to the Preadmissions Office for an interview. Preadmissions personnel counsel and advise the patient of what to do and expect (Meccia, 1989). Patients are told what time to arrive for admittance depending on the surgery schedule and lab work needed.

A&D. After the preadmit interview and before the patient is admitted, the Preadmission Office sends the AF form 560 to Admissions and Dispositions (A&D). According to the officer in charge of admissions it is possible to get the AF Form 560 "Authorization and Treatment Statement" weeks before the admission, but that is not desirable (Meccia, 1989). Since there are often changes in schedules, A&D prefers to get the AF Form 560, with final changes about one week before the patient is admitted (Meccia, 1989). He says receiving the Form 560 one week prior helps his staff to manage their time most effectively.

Bed Availability. Allocating beds to patients is determined by A&D based on a bed census report taken every night at midnight. The A&D staff person begins making bed assignments for incoming patients at about 0300 on the day of admissions. Bed assignments are based on "bed availability", meaning the bed is physically empty and no patient is assigned to bed (it is unoccupied) (Meccia, 1989). It is possible for a patient to be admitted to the hospital and released on a temporary pass lasting several days. If so, the bed the patient used is empty but is still considered occupied and unavailable.

Day Of Admittance. Most patients arrive on the day of admittance between 0600 and 1000. Their first stop is the Admissions and Dispositions Office. Even if a bed is available at that time, the patient may not be assigned it (Meccia, 1989). A&D is clearly concerned with keeping beds open as long as practical in case a higher priority patient arrives from either the Emergency Room or the Aero Evac System. Past bed management practices have resulted in turning away Scheduled patients. For example, during November 1987 four patients scheduled for admissions were refused beds and sent home due to higher priority patients arriving (Wong, November, 1987).

After being briefed at Admissions, the patient gives a nursing history and is then sent to hospital labs for lab work. The lab work that is done depends on the reason for admittance and stops may include blood work, x-rays, and EKG's (Wong, November, 1987). The patient arrives at the Preadmit Office around 1100. After relevant data are entered into the computer, the patient has vital signs taken.

At 1200 the patient may go to lunch or return home to pick up suitcases. After lunch, the patient may go to the Perri Room for an anesthesia briefing (if necessary). In the Perri Room, at the end of a long wait, the OR nurse takes another nursing history and gives a tour of the operating room and anesthesia office. Finally, the anesthesiologist briefs the patient who then returns to A&D and receives a bed (Wong, November, 1987).

The previous section described the Medical Center Scheduled admissions process via the preadmit program. Some scheduled patients do not go through the preadmit program, but rather do all their paperwork and lab work the day of admittance. In either case, on the day of admittance, the entire process begins in the morning when the patient arrives and may last until 1600 hours. One administrator who was admitted to the hospital described the process as "tiring, long and confusing..." (Wong, November, 1987).

Sources Of Admittance. Patients may also enter the hospital from three other sources: the Aero Evac System, the Emergency Room, or the Same Day Surgery Unit (SDSU) (Figure 6). A patient entering the hospital ward from SDSU had been expected to return home after surgery. When they required an extended stay, they became an unplanned and unexpected admission. A ward nurse explained in May of 1989, "Almost daily our hospital ward receives patients from 'Same Day Surgery'...[a] lot of these patients are discharged the same day...There are however instances where a planned patient from the SDSU, after recovery needs to be admitted due to unforseen problems with these recoveries or a slower than usual recovery response" (Fry, 1989).

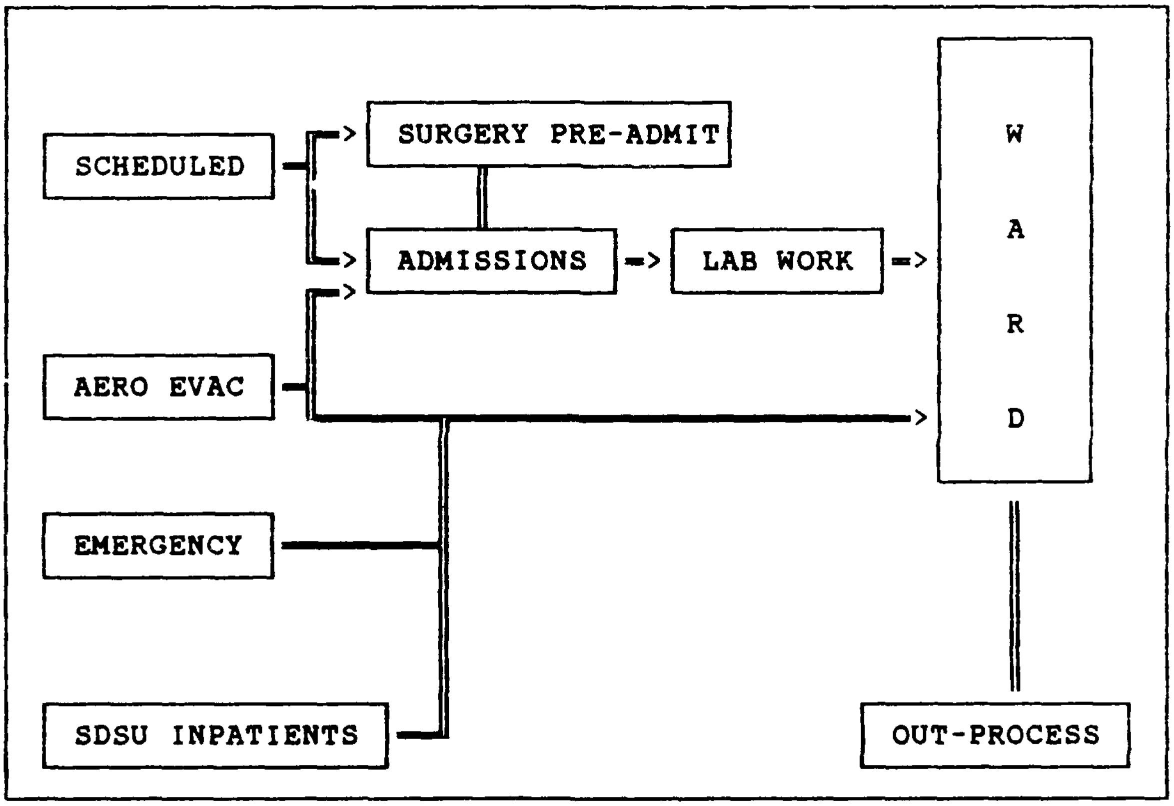


FIGURE 6: THE ADMISSIONS PROCESS (Meccia, 1989)

<u>Scheduled</u>. Patients from the four sources of admissions inprocess differently. As described above, some Scheduled patients, usually Surgery pre-admit patients, may complete their paperwork and lab tests before the day of admissions. Then on the day they are admitted, they visit the

admissions office and complete additional lab work if necessary before going on to the ward. Scheduled patients who do not go through the preadmission process do the preadmission work the day of admission prior to going to the ward.

Aero Evac And Emergencies. Aero Evac patients typically enter the hospital by visiting the Admissions Office on the day of admission and doing their lab work prior to going to the ward. There are some Aero Evac patients who arrive as Emergency patients and enter directly onto the ward. If the patient is an emergency, formal admittance waits until the patient is settled. Then lab work is done as needed, and admissions personnel come to the ward to get necessary admission information (Meccia, 1989). For admission to the Medical Center, Emergency arrivals are handled the same way as Aero Evac Emergencies.

Same Day Surgery. Same Day Surgery patients enter wards unexpectedly. Originally scheduled to go home after surgery, complications sometimes require the patient stay a day or two longer. A bed is found, and the admissions office is notified for the paperwork change (Fry, 1989).

Dispositions. Patients are admitted for many reasons and will remain hospitalized until the doctor signs release orders. The patient processes out by going to the Admissions and Dispositions Office, the funds office, and other offices as needed (Meccia, 1989).

Summary. Every patient entering the hospital goes through this admissions process although it may be in a different sequence. The hospital administrator in charge of Admissions and Dispositions says an admission takes "about 12 minutes" (Meccia, 1989). However, patients may feel visiting labs for many hours are also part of the admissions process which actually takes hours. This brief overview of the admissions process serves as a foundation on which to examine various factors affecting bed availability.

Who Schedules Beds?

An important question asked during interviews was, "Who is responsible for the scheduling of beds?" While the question appears straightforward, the answer is not. Originally, the A&D office scheduled patients into beds based on A&D personnel's opinion of where those patients should go (Meccia, 1989). A&D personnel were responsible for bed management. However, in 1987, clinical specialties were given more control over beds (Knoop, October, 1987). Clinical specialties were assigned a certain number of beds. This change allowed the A&D office to assign patients to beds based on referring clinical specialties rather than A&D personnel's opinion of where the patient should go. The clinical specialty scheduled patients to enter the hospital; A&D's role was to assign beds.

This sharing of roles has added confusion. It is unclear who is actually responsible for scheduling beds. Colonel Steve

McDonald (1989) is Chairman of the Medicine Department. His department is one of the chief users of beds. He says "no one" schedules beds. It appears he means there is not a formal scheduling process in operation by either a clinical specialty or A&D.

Is There A Scheduling Process? Two major parts of scheduling in the business world are assignment and sequencing (Bedworth and Bailey, 1987:245). These major parts will be presented in a business perspective, and then discussed as they might relate to a hospital.

In the process of scheduling, deciding on what items to work with is called an assignment (Bedworth and Bailey, 1987:245). In a hospital this assignment decision might be who should enter a ward. This assignment procedure is mainly accomplished by physicians through their clinical specialty. If there is a bed available, the A&D office simply places the patient where he should go based on the patient's attending clinic. If unscheduled patients arrive, then A&D makes the bed assignment.

Deciding the order items should be worked is called sequencing (Bedworth and Bailey, 1987:245; Meredith, 1987:580). In a hospital, this sequencing decision might be when a patient should enter the hospital. It is a priority decision. This decision is also made by the attending clinical specialty based on the priority of patient illness and other circumstances.

All schedules are sequenced according to a priority rule. The priority rule is used to help the planner to schedule. The rule chosen depends on what the scheduler wants to accomplish and the rule directly affects the type of sequencing that is done. There are four typical priority rules used in sequencing in the business world (Meredith, 1987:583-585).

1) First Come, First Serve. A hospital attempting to give care fairly might use a first come, first serve priority rule. Patients would be placed in beds based on order of arrival.

2) Due Date. A hospital wanting to ensure no patient's care is excessively delayed might use a due date priority rule. Patients would be placed into beds depending on when the physician or patient wants the hospital stay to be complete or "due". For example a patient may need an operation within the next six months as determined by the physician. The patient wants the operation done as soon as possible, but prior to his daughter's graduation ceremony. The attending physician estimates one day for surgery, two days for in hospital recovery, and two weeks for home recovery. He decides the operation's due date is no later than two and a half weeks prior to the graduation. Thus the physician and the patient have worked together to determine an acceptable due date.

3) Minimum Slack. A hospital wanting to provide services to patients whose care cannot be delayed would be using a minimum slack priority rule. A heart attack patient arriving in the Emergency Room is given care and a bed before a Scheduled patient whose health will not be jeopardized by the delay.

4) Shortest Operating Time. If a hospital's goal were to maximize the number of patients processed through the hospital, a hospital would use shortest operating time. Patients would be placed into a bed based on how long their estimated stay would be, with those having shorter stays getting priority.

There are other rules, but these are the ones commonly used in business. None of the commonly used priority rules work well in a medical setting. Currently the A&D office uses the first rule, "First Come, First Serve", to schedule beds. This rule is further defined, but not governed, by priorities of patient admissions and the availability of beds. A&D simply begins to schedule three hours before a patient shows up for hospital admission by determining the number of available beds based on the midnight census (Meccia, 1989). In general, beds are given out later that day to whoever showed up first in the morning.

This almost casual approach to scheduling hospital beds is not unusual. As the journal literature shows, scheduling is an industry wide problem. Phil Smith, an Operations Researcher at the large and local Miami Valley Hospital says Miami Valley Hospital, like WPMC, does not use any special tools or procedures to schedule patients (Smith, 1989). Though Miami Valley has 850 beds, they operate in much the same way as WPMC.

WPMC might determine its own priority rule and schedule beds based on that. In fact, an informal rule may already be in use. In order to develop a formal rule, WPMC would have to know what their goal is for patient scheduling and be willing for all clinical specialties to work toward that goal.

Though not obvious, hospitals do make patient assignments and enter them into the hospital in a certain sequence. These two factors, assignment and sequencing, taken together, constitute the two major scheduling tasks. Clearly patients are being scheduled into beds at WPMC, but many aspects of scheduling may be inadequate including the "First Come First Serve" priority rule used to sequence patients. The expression "no one" schedules beds is not technically true, but may indicate a need to improve the scheduling process.

Finding A Bed. Note bed assignments are based on the beds unoccupied at the midnight census. When making the initial bed schedule, A&D does not consider proposed departures following the census, since it is possible a doctor might cancel a proposed departure.

After the unoccupied beds are assigned, it is possible there are still patients who have not been assigned a bed. Those patients are assigned beds as they become available, assuming the patient is not pre-empted by an Emergency arrival. In theory beds become available as soon as the previous patient clears it (Meccia, 1989). The doctor must see the patient, sign release orders, and the patient must physically process out of the hospital (Meccia, 1989, Murray, 1988).

A physician must see a patient before releasing him. The hospital does not specify exactly when a doctor should make his rounds. It may be almost any hour of the day or night (Meccia, 1989; Drake, 1989). Since a physician must schedule rounds between outpatient appointments, performing surgery, and various administrative and Air Force responsibilities, visiting inpatients is not always easy. After examining the patient, the doctor may elect to release him and by signing and placing the release order in an out box (Drake, 1989). If given prior warning, the nursing staff will try to fill prescriptions and prepare paperwork ahead of release to help clear the patient quickly. However, if the nursing staff has no advance notice of the release, getting the paperwork done and filling prescriptions may delay the release of a patient.

Once released, the patient must vacate the room to allow time to prepare the room for the next patient. Timely departures have been a problem in the past. Patients who were released, possibly earlier than expected, often did not want to check out until their home care provider arrived to take them home (Drake, 1989; Meccia, 1989; Murray, 1988). The home care provider might arrive too late in the day for the hospital to schedule a new patient into the bed. Thus a patient who could have had a bed was not given one. Though a policy letter was released (Murray, 1989) mandating an 1100 check out time, many of the hospital staff appear reluctant to enforce the policy (Murray, 1989).

The process of letting the A&D office know a bed is available seems to be rather haphazard. Releasing a bed depends on when the doctor shows up on the ward to make his rounds. Then patient release depends on how long it takes the physician to examine the patient, visit other patients, and write up release orders. At this time the ward only knows a bed is being released, not exactly what time the bed will be available for a new patient. There is no enforced check out time for the patient, and when he does leave, the ward must still notify housekeeping to change the bed linens.

The ward does not call A&D when a bed is being vacated (Drake, 1989). In fact, A&D may not know about a vacant bed until the vacating patient shows up in the office for outprocessing (Meccia, 1989). If A&D happens to call the ward, A&D will discover the upcoming vacancy. Communication between the ward and A&D is by phone if at all. Though there is at least one computer network operating in the hospital computer center, many offices do not have terminals that might provide real time information.

Thus scheduling becomes a chain reaction. After the initial bed allocation based on the beds open at midnight, the Admissions and Dispositions Office often finds several more beds are needed. Availability of the additional beds depends on many factors outside the control of A&D. Furthermore, the process of A&D finding out a new bed is available for occupancy can take between two and a half hours (Murray, 1989) and five hours (Drake, 1989). This does not appear to affect the actual assigning of beds. A&D is able to respond quickly to the information. Assuming there are patients needing beds, the time between patient occupancies, averages a half hour to an hour (Drake, 1989; Meccia, 1989).

Even if a bed is available, and a patient is formally assigned the bed, most patients are usually not allowed to visit their room until late afternoon (Meccia, 1989). If those patients check in with Admissions and Dispositions in the morning, they must carry their baggage with them during the lab work, or leave it in the A&D office, or go home at lunch to get their baggage. It is not unusual to see suitcases sitting next to empty chairs in the A&D office. If a bed was actually available, and the patient insisted, A&D would allow the patient to drop his baggage off in the assigned room. The normal procedure though, is for the patient to go to his room at the end of the day (Meccia, 1989). The reason for this procedure is to allow time to prepare beds. This also leaves open beds for Emergency patients.

What Is The Admissions Goal Of WPMC? As in any unit, the goal, whether explicitly stated or not, determines how the unit operates. The stated goal of the hospital is to provide excellent customer service. The officer in charge of the Admissions and Dispositions Office agrees with that goal (Meccia, 1989). He says the A&D office wants to provide fair access to hospital services for all legitimate users. This goal couples nicely with the medical profession's "care provider" orientation.

On the other hand, sometimes a business perspective other than caring for a patient is necessary as was discussed earlier.

The "business" orientation would support the policy of releasing a patient as early in the day as possible to free up a bed for a new patient. This policy improves customer service and is good business. Yet, it appears it is difficult for hospital staff to put aside their care provider role and enforce policies that would be good for other patients. Hospital staff may concentrate on the patient in their care rather than the one they can not see. Drake (1989) said the goal is to accommodate the patient in *their care* if at all possible (Drake, 1989).

There is a second non stated goal. That is to provide excess bed capacity (to ensure beds remain open as long as possible) to accommodate emergencies. The Medical Center cannot afford to maintain 100 percent occupancy, but instead wants to allow room for contingencies (Meccia, 1989).

It is significant to note what the goal is not. It is not to provide service to the maximum number of patients as possible. The goal is not to minimize idle beds nor to maximize the use of beds. The goal is to care for patients; critical care first, and Scheduled admissions second.

Investigative Question Two

Do hospital administrators think there is a bed management problem, and if so, what factors do they think affect bed availability?

The answer to this question came from a four page, self-administered, questionnaire given to hospital personnel involved in the bed management process (See Appendix I). The questionnaire was sent to 84 hospital personnel involved with bed management. The return rate was strong, with sixty-two (78.8 percent) respondents returning.

The typical respondent was 31-40 years old, a Major or Lt Colonel, and male. He had a doctorate, was a physician and was associated with either the Medicine clinic or the Surgery clinic. Most had less than one year of experience at WPMC.

The questionnaire was divided into three parts: demographic questions, questions about possible problems of bed management, and one open-ended question. The questionnaire results were briefed to the Wright Patterson Medical Center Bed Management Process Action Team (PAT) during their June 1989 meeting (Process:1989). Their comments will be addressed in applicable sections.

Discussion Of Demographic Questions

Seven demographic questions were asked concerning age, military pay grade, gender, degree, primary job, medical service and experience. Each factor will be discussed separately.

Age. Interestingly, all respondents were over 31 years old (Table 5). Most (65 percent) were in the 31-40 year age group. The next largest group, 41-50 year age group contained 28.3 percent of the respondents, and the rest of the respondents were older. The demographics of age can be explained by the survey population (i.e. people who actually make the decision about beds). Those people tended to be upper level management rather than entry level personnel.

TABLE 5 : SURVEY - AGE

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
31-40	2	39	62.9	65.0	65.0
41-50	3	17	27.4	28.3	93.3
51-60	4	4	6.5	6.7	100.0
MISSING	10	2	3.2	MISSING	
		-------	-------	-------	
	TOTAL	62	100.0	100.0	

<u>Military Pay Grade</u>. Only five respondents (8.3 percent) were Lieutenants or Captains (Table 6). Most were Majors or Lt Colonels (63.3 percent), while 26.7 percent were Colonels. One respondent chose a "not applicable" response. Since the questionnaire was only sent to military officers, the response is unclear.

TABLE 6 : SURVEY - PAY GRADE

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
O-1/O-2/O-3	1	5	8.1	8.3	8.3
O-4/O-5	2	38	61.3	63.3	71.7
O-6 and above	3	16	25.8	26.7	98.3
Not applicable	4	1	1.6	1.7	100.0
MISSING	10	2	3.2	MISSING	
		-------	-------	-------	
	TOTAL	62	100.0	100.0	

Gender. Eighty five percent of the respondents were male, while fifteen percent were female (Table 7).

TABLE 7 : SURVEY - GENDER

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
Female	1	9	14.5	15.0	15.0
Male	2	51	82.3	85.0	100.0
MISSING	10	2	3.2	MISSING	
		-------	-------	-------	
	TOTAL	62	100.0	100.0	

Education Level. Four levels of higher education were given as possible choices (Table 8). One respondent (1.7 percent) said a bachelor's degree was his highest level of education. Five respondents had a master's degree and accounted for 8.3 percent of the responses. Another 48 (or 80 percent) of the respondents had doctoral level education. Six more (10 percent) said they had other degrees.

TABLE 8 : SURVEY - EDUCATION LEVEL

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
Bachelor	2	1	1.6	1.7	1.7
Master	3	5	8.1	8.3	10.0
Doctoral	4	48	77.4	80.0	90.0
Other	5	6	9.7	10.0	100.0
MISSING	10	2	3.2	MISSING	
		-------	-------	-------	
	TOTAL	62	100.0	100.0	

Primary Job. Of the four possible job choices given to the respondents 46, or 76.7 percent of the respondents chose physician (Table 9). Administrative nurses made up another 10 percent, and administrative physicians made up another 8.3 percent. A final category was administrative others. They made up 5 percent of the responses.

A t-test was performed at $\alpha = .05$, comparing responses of physicians and administrative physicians. It confirmed that the two physician groups were not significantly different except on the question of the admissions office controlling access to beds. For that question, the two groups were considered different. For all other questions, the combination of those two groups were referred to as "grouped physicians".

TABLE 9 : SURVEY - PRIMARY JOB

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
Physician	1	46	74.2	76.7	76.7
Admin Nurse	2	6	9.7	10.0	86.7
Admin Physician	3	5	8.1	8.3	95.0
Admin Other	4	3	4.8	5.0	100.0
MISSING	10	2	3.2	MISSING	
	TOTAL	62	100.0	100.0	

Medical Service. This demographic variable indicated the clinic with which the respondent was most closely identified (Table 10). Nine choices were available as possible medical service association. The Medicine clinic had the largest group with 30 percent of the respondents claiming it as an affiliation.

The next highest group was Surgery with 21.7 percent of the responses. Third highest was Pediatrics with 13.3 percent. "Administration or other" also claimed 13.3 percent of the responses. The rest of the medical services scored below 7 percent each.

TABLE 10 : SURVEY - MEDICAL SERVICE

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
Medicine	1	18	29.0	30.0	30.0
Surgery	2	13	21.0	21.7	51.7
Urology	3	2	3.2	3.3	55.0
Orthopedic	4	4	6.5	6.7	61.7
EENT	5	1	1.6	1.7	63.3
Mental Health	6	2	3.2	3.3	66.7
Pediatric	7	8	12.9	13.3	80.0
OB/GYN	8	4	6.5	6.7	86.7
Admin./Other	9	8	12.9	13.3	100.0
MISSING	10	2	3.2	MISSING	
	TOTAL	62	100.0	100.0	

Experience. A question designed to evaluate experience with WPMC's bed allocation policies used the number of years at WPMC as its criteria (Table 11). Out of six choices ranging from "below one year" to "more than five years," the responses were very evenly distributed. "Less than one year" made up 26.2 percent of the responses. "One year but less than two" and "two years but less than three" made up 19.7 percent of the responses each. "Three years but less than four", and "four years but less than five" made up 11.5 percent each and "more than five years" accounted for 13.1 percent of the responses. The low level of experience at WPMC is expected given the typical three-year Air Force tour.

TABLE 11 : SURVEY - YEARS AT WPMC

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
<1yr	1	16	25.8	26.2	26.2
1yr but <2yr	2	12	19.4	19.7	45.9
2yr but <3yr	3	11	17.7	18.0	63.9
3yr but <4yr	4	7	11.3	11.5	75.4
4yr but <5yr	5	7	11.3	11.5	86.9
>5yr	6	8	12.9	13.1	100.0
MISSING	10	1	1.6	MISSING	
	TOTAL	62	100.0	100.0	

Ranking Of Problems

Questions. After the demographic questions were asked on the questionnaire, questions were structured to determine possible problem areas. Every question in the second part of the questionnaire began with the statement stem "Bed Management at WPMC has been made more difficult in part by....". Following the stem was a list of 26 variables that could affect bed management. The variables were drawn from the literature review, interviews, and personal observations.

Each respondent could chose between "one", meaning strongly disagree, and "five", meaning strongly agree, with "three" being neither agree nor disagree. The average response of each variable was determined and all of the variables were ranked based on their average. The variable averages were between 2.34

and 4.25. The results are summarized in Table 12. To see complete item descriptions, see the complete survey included at Appendix I.

A quick look at the top five variables show a capacity problem. Respondents appear to think there is not enough staff and not enough beds. There is also a demand problem, seen in the unpredictability of arrivals. The variable "ratio of staff to beds" was rated highest with a 4.25 rating, or somewhere between agree and strongly agree. The next two rankings, "having too few beds" (in general) and "the availability of critical care beds" appear to measure the same thing. A reliability check however, yielded a low .20 reliability. Steel (1989) rates reliabilty as .70 = fair, .80 = good, and .90 = excellent. It appears the respondents see a difference in the two variables. The next two variables, unpredictability of Emergency arrivals and the unpredictability of Aero Evac arrivals also appear to measure the same problem. A reliability check of them was also weak, with a .34 reliability coefficient. It seems all five top ranked variables were considered as separate and different variables by the respondents.

Open-ended Comments

The third part of the questionnaire gave respondents the opportunity to respond to an open-ended question concerning bed management or anything else they wanted. The question stated,

TABLE 12 : VARIABLES AFFECTING BED MANAGEMENT

"The bed management process is made more difficult in part by..."

Rank	Score	Item	Item Description
1	4.25	14	...staff to bed ratio limiting # of beds.
2	3.89	9	...having too few beds.
3	3.88	33	...the availability of critical care beds.
4	3.82	19	...the unpredictability of Emerg arrivals.
5	3.78	18	...the unpredictability of Aero Evac arrivals.
6	3.71	28	...a lack of an adequate information system.
7	3.68	15	...OR schedule affecting admissions schedule.
8	3.64	27	...a lack of an accurate forecast.
9	3.49	13	...patient factors such as disease & gender.
10	3.48	21	...a lack of modern admin. technologies.
11	3.44	22	...no one responsible for scheduling beds.
12	3.42	24	...communication between A&D and wards.
13	3.41	10	...distribution of beds among med. services.
14	3.33	11	...inability to determine patient LOS.
15	3.27	31	...hospital policies regarding use of beds.
16	3.25	30	...hospital policies regarding MEB's.
17	3.20	26	...lack of an bed reservation system.
18	3.15	29	...communication between medical services.
19	3.12	8	...hospital construction.
20	3.10	23	...lack of a scheduling procedure.
21	3.02	12	...failure of released patients to leave room.
22	3.02	25	...scheduling too many patients at a time.
23	3.00	17	...admissions office controlling bed access.
24	2.61	32	...number of same day admissions patients.
25	2.44	16	...physicians controlling access to beds.
26	2.34	20	...preadmissions program

"Please describe any other problems concerning the bed management process that are not listed in the questionnaire or make any further comments that you wish". Some of the comments are sampled here.

Staff To Bed Ratio. On the variable, Staff to bed ratio limiting the number of available beds, one respondent wrote, "Main problem is the lack of beds, i.e. the lack of enough support staff to open enough beds. This is followed closely by .... the lack of enough support staff to open all the ORs". Another respondent saw a staff shortage in critical care units saying, "Our critical care units are grossly under staffed, as is the anesthesia department". A third respondent emphasized nursing shortages. He said, "Promises to add nursing staff to maximize our bed utilization have not been forthcoming--not in the numbers required--and [it] is an Air Force (not local) problem..." The same idea was put more forcefully by a respondent who seemed to see an imbalance between staff and line personnel. He said, "Hire more nurses! Convert administrator slots to nursing slots! Contract out the hospital administration!"

One person who said he "did not know what the problems are" still supported the staff shortage complaint through what he'd heard. He said, "I don't know why the bed problem is so bad here compared to other bases I have been at. I am only at the end of the line and don't know what the problems are. I have been told we don't have enough nurses and ward techs--but I don't know if that is the real problem."

Having Too Few Beds. Comments addressing the bed shortages were also numerous. Sometimes it showed up in a specific complaint dealing with a clinical specialty. "Don't have enough Medical beds," said one respondent. At other times respondents complained about bed distributions. "It is possible that Medicine has too many beds and Surgery does not have enough!" typified such a response. And still others wrote, "Beds available to the surgical specialties are in great disproportion to those available to the Medicine services" or "Pediatrics has too many beds allotted-never seems to be full".

A close look at the database showed that the Pediatric ward in 1988, is currently allocated nine beds, but never had more than eight patients at time. The reason may be due to the ward closure. However, it may simply be due to low demand for Pediatric beds.

Having too few beds does not always mean beds are full. Sometimes beds are physically empty but not available. A comparison to civilian hospitals lead one respondent to write, "Many beds go unused because the patients are out on pass. Out on pass is not allowed in the civilian sector for very good reasons. It is not cost effective. It should be eliminated for non-active duty patients. Either a patient needs to be in the hospital or he does not. It is that simple." One unusual comment was, "I have not found a difficulty in managing admissions or obtaining beds".

Availability Of Critical Care Beds. Critical care beds received several comments. A respondent wrote, "Critical Care bed availability is often a key decision maker for admission." Another respondent also noted the critical care bed shortage saying, "I am also aware of the severe problem with ICU beds not because I admit that many patients to the ICU but because I am frequently consulted for problems which the patients develop". A respondent noted, "Giving 'pre-admit' patients priority over patients waiting to move out of the ICU's [is a problem]. ICU patients should have first priority. Otherwise, critically ill patients cannot be admitted because ICU beds fill up with non-critical patients. More beds are needed just for flexibility. The whole system bogs down when beds are tight and physicians have to spend time finding beds or waiting for patients to be admitted."

Comments On Arrivals. Although the unpredictability of Emergency and Aero Evac arrivals were rated as number four and five, there were no comments on them. Perhaps the respondents saw this area as unchangeable and therefore declined comment.

Summary Of Major Problems. Several respondents used the open-ended comments section to summarize the problem in their own way. One respondent said, "Real problems with bed situation: 1. too few beds, 2. too few nurses, 3. if #1 and #2 were addressed, there would not be a bed shortage problem." Another thought it was a "tough problem with no easy answers". A third respondent showed his agitation with using available resources vs simply getting more resources. He said, "This is a major medical center. We need more beds and more nurses, more OR time. We don't need fancy computers to juggle what is an inadequate number of beds."

Discussion Of Analysis Of Variance

An Analysis of Variance (AOV) was conducted on the job demographic variable (question 5), the medical service variable (question 6) and the experience variable (question 7). The intent was to find if there were response differences based on these different types of groups. When differences were noted a Student-Newman-Keuls (SNK) test was performed at $\alpha = .05$. The SNK test showed that on most factors of bed management the groups had no difference. Only 5 of the 26 possible factors of bed management problems showed differences in the job and medical service variables and only 1 of the 26 possible factors showed a significant difference on the experience variable.

AOV And Job Variable

A one way analysis of variance was conducted on the job demographic variable (question five). Out of the five possible responses to the question, "How would you classify your current primary job", 46 responded "Physician", 6 responded "Administrator-nurse", 5 responded "Administrator-physician", and

3 responded "Administrator-other" [than nurse or physician]. Physicians and administrative physicians were grouped together and called "grouped physicians" except where noted.

Five of the bed management variables showed a significant difference when examined by type of job. Those bed management variables were "inability to determine length of patient stay", "failure of patients to leave when released", physicians controlling access to beds", "admissions office controlling access to beds", and "communication between services".

Inability To Determine LOS. The inability to determine in advance how long a patient would stay in the hospital drew a difference between administrative others and grouped physicians at a p value = .067. The administrative others group consisted of three administrators and the grouped physicians consisted of 50 doctors. The administrative other's mean was five, or the highest it could be, while the grouped physician's mean was 3.35.

The difference in the two groups may be due to a difference in perspective. Administrative others may view all clinics as a whole, while the physician's view is primarily centered on a particular clinic or a single patient. Administrative others are concerned with the overall operations of the hospital. They may think if the length of stay could be determined more accurately, then patients could be scheduled better, and bed management would improve. Grouped physicians however, may view the length of stay as determined by a combination of factors such as the patient's health, available staff and resources to care for the patient, and the amount of time it takes to release and outprocess that patient. The difference in perspective may have caused the two groups to view this variable differently in regards to better bed management.

During the PAT briefing (Process, 1989), it was suggested administrative others might think physicians could control the length of stay better. One administrator present, who had chosen administrative other on the questionnaire, said he simply thought length of stay was a major factor all by itself without any regard to physicians.

Failure Of Patients To Leave. Grouped physicians had a significant difference of opinion with administrative others at a p value = .0195 on the subject of patients leaving beds after being released. Since the Admissions Office can not issue a bed until a patient leaves, those administrators may see a patient's delay as a real problem. Grouped physicians, on the other hand may think that many factors delay getting a patient released. During the PAT briefing, this item was discussed. The physicians noted that even if orders were written up the night before, the patient might not leave any earlier. It depended on when the nurse had completed her paperwork, when prescriptions were filled, and many other variables. They maintained, if there was not demand for the bed, there was no harm in letting the patient delay his departure (Process, 1989).

Other PAT members noted the main reason patients didn't leave when released was because they were waiting for a ride.

When asked if patients were ever told when to expect to leave, the consensus was "No". Patients were given a general morning or afternoon time frame. The PAT team was also unsure of a definite hospital policy stating when a patient should vacate their room and discussed creating such a policy (Process, 1989).

Perhaps the difference of opinion on this variable is seen in the following comment where patients are allowed to stay for convenience rather than for health reasons. The respondent stated, "The practice of extending the patient's hospital stay for convenience sake rather than discharging patients [happens much to often]."

Physicians Controlling Access To Beds. On the question of physician's controlling access to beds, grouped physicians differed with administrative nurses. The p value was .001. There were six administrative nurses, with a mean on this variable, of 4.0. The grouped physicians had an average mean of 2.2.

Obviously, grouped physicians either do not see themselves as controlling access to beds, or do not see themselves as part of the bed management problem. Nurses, on the other hand, chose "agree". They said physicians controlling access to beds does make bed management more difficult.

Grouped physicians may see themselves as having control over access to beds but not as making bed management more difficult. As discussed earlier, in "failure of patients to leave", physicians appear to see many factors affecting control of beds.

They see themselves as simply one factor, not a major factor. Many respondents, however, pinpointed the physician as responsible for bed handling. One respondent to the questionnaire not only said physicians were "most responsible", but specifically challenged physician bed coordinators saying,

> Physicians ... in themselves do not make the problem more difficult. They are, in fact, [one of] the parties most responsible for bed assignments ... We have physician bed coordinators, nurse level coordinators all communicating to A&D personnel. My question is: I know that A&D personnel and nurse bed coordinators are involved, but are the physician bed coordinators actively involved day to day?

A&D Controlling Access To Bed. This variable was the only one where physicians and administrative physicians differed at a p value = .051. Physicians had a mean of 2.91 and administrative physicians had a mean of 4.20. In other words, administrative physicians thought the Admissions Office's control of beds was a much greater problem than did the physicians. Since the administrative physicians are most likely at a higher staff level, they may see a problem the typical physician does not see.

During the PAT briefing, one administrator pondered the difference. He thought that since the admissions office was located in the command section of the hospital, the Admissions Office was more visible to the administrative physicians. To see the "people waiting" was a constant indicator of a problem. Thus, the administrative physicians more closely associated the admissions office with bed management problems than did the physicians (Process, 1989).

Communication Between Services. Often medical service specialties must coordinate among themselves to find beds for patients who are arriving or changing wards. Since beds are assigned to clinical services, a certain amount of cooperation is necessary. The administrative nurses showed a significant difference with grouped physicians at a p value = .024. This time the difference was over communication between medical services. Nurses still averaged 4.0, while the grouped physicians averaged 2.6.

Perhaps nurses must coordinate finding beds and find it very frustrating. Frustration was expressed in the comments section of the questionnaire. One respondent said, "...lack of cooperation of one service letting the other use its beds [is a problem] Ex: Medicine not letting Surgery use their empty bed." Another respondent said that "The propensity for another service to "borrow" a bed from Pediatrics and then, when one of their patients is discharged, another adult is put in that bed without Pediatrics being given their bed back". A third respondent said "...emergency non-elective admissions take priority over all other admissions regardless of 'service' bed availability... without any inter-department communication necessary as is on elective admissions...".

The communication problem can be seen in the following comment. "... Surgery and/or A&D fills all Surgery beds with scheduled patients, and then want one of our beds when they get an acute patient ...."

AOV On Medserv Variable

A one way analysis of variance was also conducted on the Medical service variable (question 6). Question six asked "Which medical/clinical service are your primary duties associated with?" Eight major clinics were given. For those respondents not identified with a clinic or who identified more closely with administration, a choice of administration/other medical service was given. Four bed management variables generated significant differences when responses were looked at by source of medical service.

Staff To Bed Ratio. The staff to bed ratio limiting the number of available beds was the variable most often selected by the respondents as most affecting bed management. At a p value = .011, Urology, with a mean of 2.5, significantly differed from Medicine (mean 4.667), and OB/GYN (mean 5.0). The difference is most probably due to the small number of respondents (2) from Urology.

The OR Schedule. The "effect of the OR schedule on the Admissions Schedule" variable did not score high on its over all mean. Still, there was a significant difference (p value = .0230) between OB/GYN with a mean of 5.0 versus Surgery with a mean of 3.14 and Pediatrics with a mean of 3.14. One response to the open ended question was "OR Scheduling in regard to Same Day

Surgery vs preadmitted patients has forced our department to stop scheduling Same Day Surgery." If this clinic has stopped scheduling Same Day Surgery, then there must be an increase in inpatient scheduling.

Physicians Controlling Access To Beds. This variable appeared earlier when analyzed by type of job. This time, those who identified themselves as Administration/other clinic (eight people) differed from the 18 respondents who aligned with the Medicine service at a p value = .077. The Medicine mean was 1.94 and the Administrators/others mean was 3.38.

This difference is most likely a difference between physicians, most of whom are in Medicine, and administrators. As previously discussed, certain respondents may see physicians as having control. Some comments were "Physicians do not discharge patients early in the day per Medical Center policy" or "It shouldn't be necessary to get physician's permission to 'give away' beds".

Physicians themselves don't themselves as controlling beds, and don't want the responsibility. One physicians said, "It is absolutely ludicrous for physicians to ever be given the task of having to locate their own beds for patients".

Responsibility For Scheduling. The variable "No one directly responsible for scheduling" was a significant variable at a p value = .0192. Medicine had a mean of 4.0 on this variable and differed from Surgery with a mean of 3.15. This Medicine service perspective can be seen by a comment from the

Chairman of the Medicine Department. He stated, "No one is responsible for scheduling" (McDonald, 1989).

Lack Of Forecast Of Patient Arrivals. There was a significant difference at a p value = .005. A Student-Newman-Keuls test showed Urology differed from three other clinics and Orthopedics differed from one.

Urology, with a mean of 2.0 differed from Medicine (mean of 3.89), Administrators (mean of 4.0), OB/GYN (mean of 4.33), and Mental Health (mean of 4.5). As noted before, the difference is likely due to the low number of respondents (2) from Urology. Still, the PAT team members noted that Urology, a Medicine clinic differed significantly from two other Medicine specialties (Process, 1989). Orthopedics had a mean of 2.75 and differed from Medicine with a mean of 3.87.

AOV On Experience Variable

Only one variable showed a significant difference when groups were compared by experience level. The variable was "patients failing to leave their rooms when released". Respondents with greater than five years of experience had a mean of 4.0 and differed with respondents having less than one year (mean = 3.063), and one year but less than two years (mean = 2.58). This may indicate respondents with more experience have seen an historical problem others aren't aware of.

Summary

The overall survey results showed most hospital personnel dealing with bed management agree on factors impacting bed management. Few variables showed significant differences.

Investigative Question Three

Can a simulation be created that will accurately model the bed management process?

a. What is the profile of a typical patient?

b. What are the arrival sources?

c. Is there a pattern of arrivals by day of week?

d. Is there a pattern of arrivals by week of year?

e. Is there a pattern of arrivals by month of year?

f. What is the average length of stay of patients by clinical service?

Description Of The Inpatient Population

The following statistics were computed from a sample population of the database obtained from the WPMC computer. Where specified an actual count of 100 percent of the database was used rather than the sample population.

Sex And Age (Figure 7). The sample yielded 47.78 percent females and 52.22 percent males. Ages ranged from 2 years old to 90. The largest age group was the 27 to 34 years old range with 21.1 percent of the patients. The next largest age group was the 19 to 26 year age span consisting of 18.6 percent of the

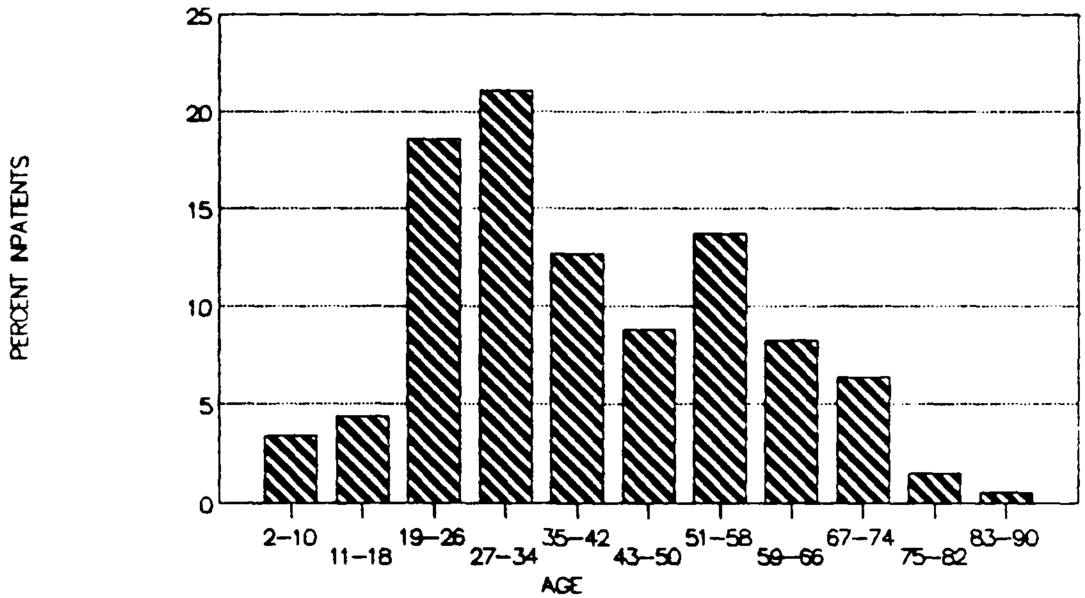


FIGURE 7: SAMPLE - AGE

population. Third largest was the 51 to 58 year age span. They were probably members and spouses retired from service about ten years. They consisted of 13.7 percent of the population.

<u>Clinical Services</u>. Clinical services used by inpatients give a general idea of how the hospital is being used by patients (Table 13). Appendix B shows a detailed breakdown of the clinical services used by patients and how long patients of those clinical services stayed. Appendix B is based on an analysis of 100% of the patient database.

The clinical specialties with the most beds were Surgery with 57 (25 percent), Mental Health with 55 (24 percent), and Medicine with 50 (22 percent). The most patient arrivals came from Surgery with 31 percent, Medicine with 26 percent, and Labor and Deliver with almost 17 percent of arrivals. The longest average length of stay was Mental Health with 30.13 days, followed by Orthopedics with 7.08 days, Medicine with 6.82 days, and Surgery with 5.77 days.

TABLE 13 : CLINICAL SERVICES

SERVICE	NUM BEDS	PERCENT ARRIVALS	AVG LOS
Cardio (CCU)	7	.0206	2.87
Gyn	11	.0720	4.96
Lab&Del	18	.1675	3.53
Ortho	21	.0938	7.08
Med	51	.2613	6.82
Men Health	55	.0451	30.13
Ped	9	.0308	3.24
Surgery	57	.3104	5.77

<u>Military Service</u> (Figure 8). Does the hospital serve an active duty Air Force or a retired Air Force? Active duty personnel and their dependents made up 61.09 percent of the database, while retirees made up 37.93 percent. Active duty personnel accounted for 33.50 percent of the population sample with dependents of active duty accounting for another 27.59 percent. Retired personnel made up 20.69 percent of the database and their dependents made up 17.24 percent. Other patients accounted for less than one percent of the database. An example of "others" would be an automobile accident that occurred close to WPMC involving a civilian who needed immediate attention. That patient would be treated at WPMC and transferred to a civilian hospital when stable. It is noteworthy that 66.5 percent of the hospital bed users are not on active duty.

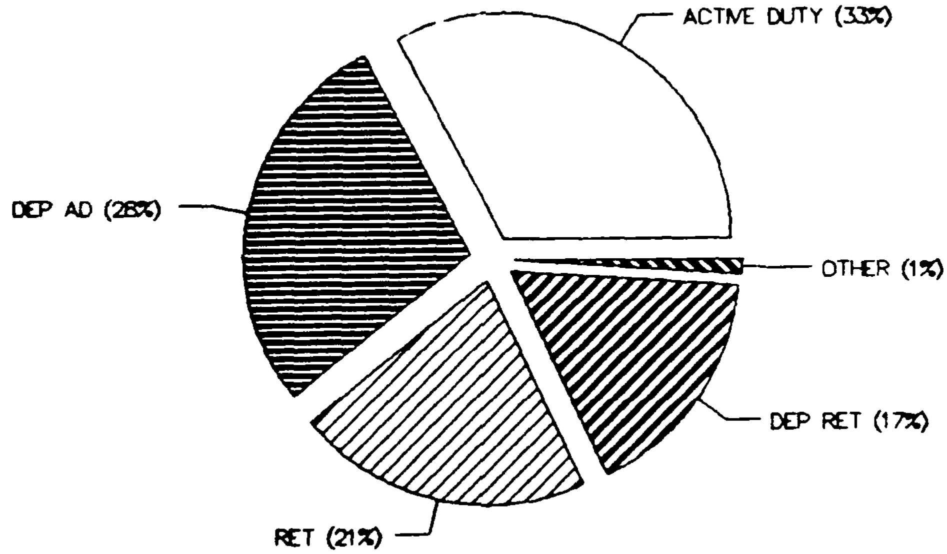


FIGURE 8: SAMPLE - ACTIVE DUTY VS RETIRED

A further examination of military service showed inpatients who were Air Force personnel, including retirees and dependents made up 66.01 of the sample population (Figure 9). Army personnel constituted another 21.67 percent of the inpatient population. Navy personnel (8.87 percent) and others (3.45 percent) made up the final inpatient group.

Groups were further separated into military service branches and examined according to active duty and dependent status. Air Force dependents, with 20.69 percent of the patient population, accounted for the largest inpatient group. Next was active duty Air Force with 19.7 percent, retired Air Force with 13.79

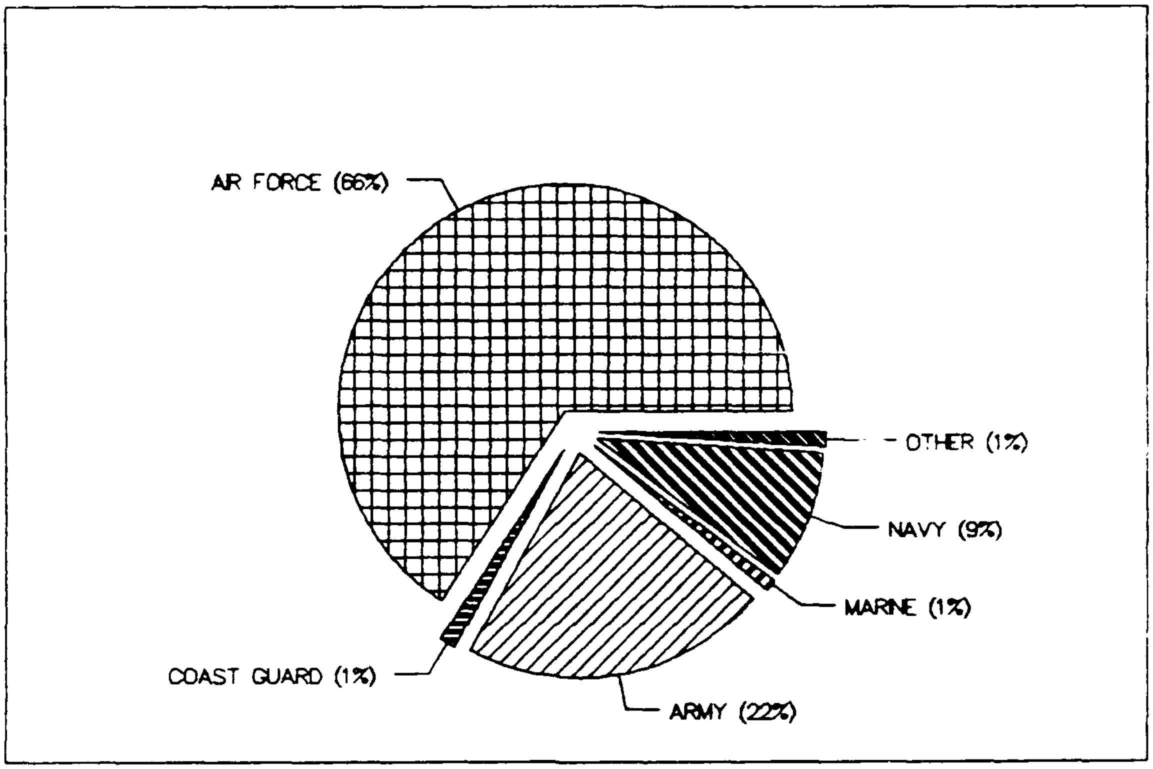


FIGURE 9: SAMPLE - MILITARY AFFILIATION

percent, and dependent retired Air Force with 11.82 percent. Other specialized groups dropped into single digit percentages. It is noteworthy that 66 percent of the hospital bed users were not active or retired Air Force personnel. See Table 14.

Locality. Patients using the Medical Center came from a variety of states (Figure 10). Local patients were those Ohio residents within 60 miles of WPMC. They accounted for 56.16 percent of the sample. Other Ohio residents made up another 20.69 percent of the patient database. Indiana residents were the third largest group, with 6.4 percent of the patient database. All other patients came from 12 states ranging from

TABLE 14 : SAMPLE - PATIENT CATEGORY

PATCAT	DESCRIPTION	CODE	PERCENTAGE
F41/43	Dependent Air Force	DAF	20.69%
F11	Active Duty Air Force	AAF	19.70%
F31/33	Retired Air Force	RAF	13.79%
F42/44	Dependent Retired Air Force	DRAF	11.82%
A11	Active Duty Army	AAR	9.36%
A42/44	Dependent Retired Army	DRAR	4.43%
A41	Dependent Active Duty Army	DAAR	3.94%
A31/33	Retired Army	RAR	3.45%
N31/33	Retired Navy	RN	2.96%
N11	Active Duty Navy	AN	2.96%
M41/N41	Dependent Active Duty Navy	DAN	1.97%
P11	Active Duty Coast Guard	ACG	0.99%
M33	Retired Marine	RM	0.99%
N42	Dependent Retired Navy	DRN	0.99%
P31	Retired Coast Guard	RCG	0.49%
A21	Reserves	RES	0.49%
M11	Active Duty Marines	AM	0.49%
X98	Other		0.49%

Michigan to the north, Maine to the east, Texas to the south and Missouri to the west.

Arrival Analysis

Detailed information including raw data and statistics can be found in Appendices D, E, F, AND G. General trends will be discussed here. Arrival information is based on List1, using 100 percent census of the patient database.

The List1 database of 9443 names was trimmed down to 7250 by deleting several categories of patients. Categories deleted were patients confined to quarters at home, Emergency Room deaths, youth under two, and Same Day Surgery. Keeping in mind assumptions made in Chapter Three, the trimmed down list was examined to calculate accurate arrival rates. The three arrival process: Aero Evac, Emergency, and Scheduled had their unique characteristics as well as cumulative characteristics.

Inpatient Arrivals. Patients who actually used WPMC beds came from three sources: Emergency arrivals (13 percent of the total), Aero Evac arrivals (8 percent), and Scheduled arrivals (79 percent of the total).

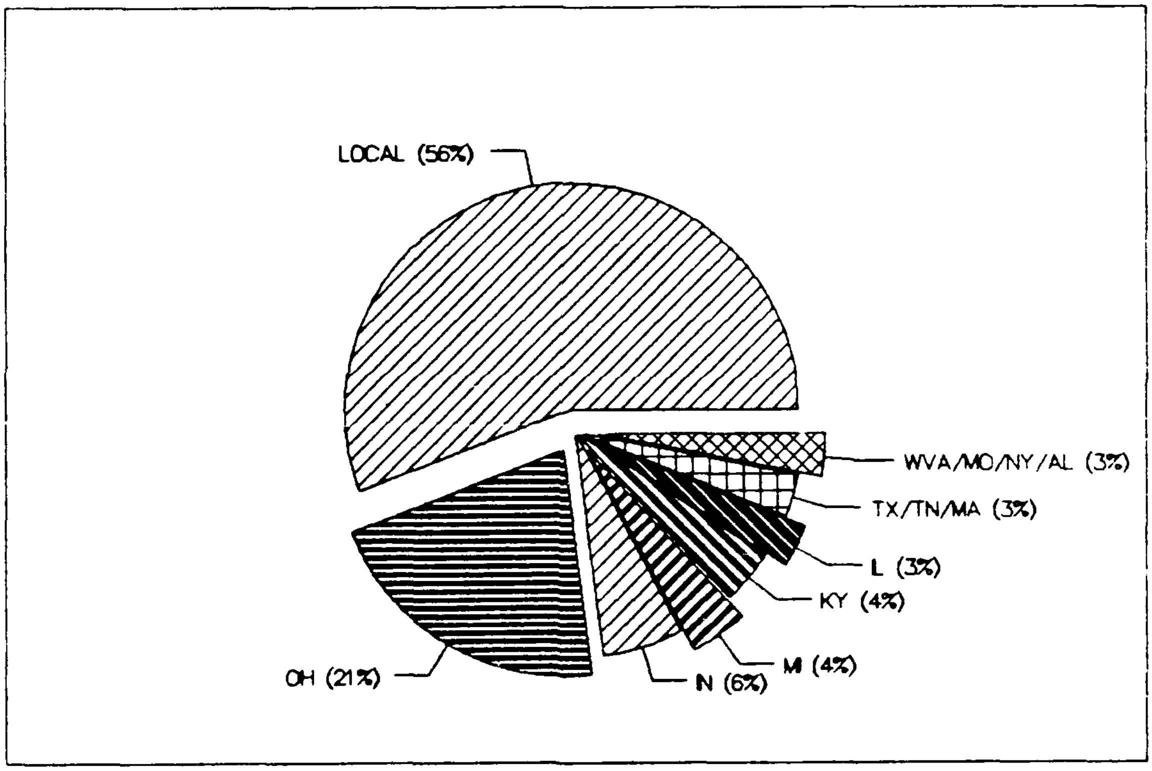


FIGURE 10: SAMPLE - LOCALITY

Emergencies (Table 15 and Figure 11). Emergency arrivals were computed by adding up arrivals that had been labeled an Emergency in the database. These made up 13 percent of all arrivals. Most Emergencies tended to arrive on Sundays and

Thursdays with the days prior, Saturday and Wednesday, being the low points of the week. The yearly mean for Emergency arrivals was 2.47 a day. WPMC could easily predict Emergency arrivals by

TABLE 15 : CENSUS - EMERGENCY ARRIVALS

	SU	MO	TU	WE	TH	FR	SA
INPATIENTS	143	140	125	120	155	127	125
STD	1.73	1.99	1.44	1.98	2.55	1.87	1.83
MEAN	2.75	2.59	2.31	2.22	2.87	2.31	2.27

day of week by choosing a worst case scenario for each day. For example, a possible arrival for Thursday would be 8.29 Emergency patients (mean plus two standard deviations).

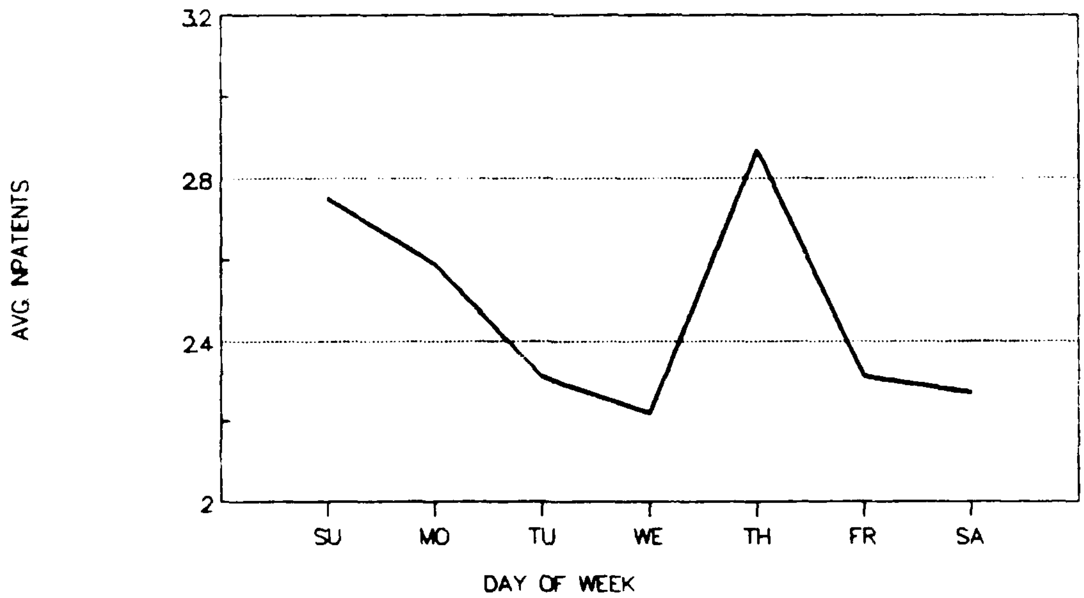


FIGURE 11: CENSUS - EMERGENCY ARRIVALS

Aero Evac (Table 16, Figure 12). Aero Evac aircraft arrivals totaled 203 for 1988. Most of those aircraft arrivals,

TABLE 16 : CENSUS - AERO EVAC ARRIVALS

	SU	MO	TU	WE	TH	FR	SA
AE AIRCRAFT	11	57	3	50	7	52	23
AE INPATIENTS	34	136	14	131	14	194	69
MEAN INPATIENT	.65	2.62	.27	2.52	.27	3.73	1.33

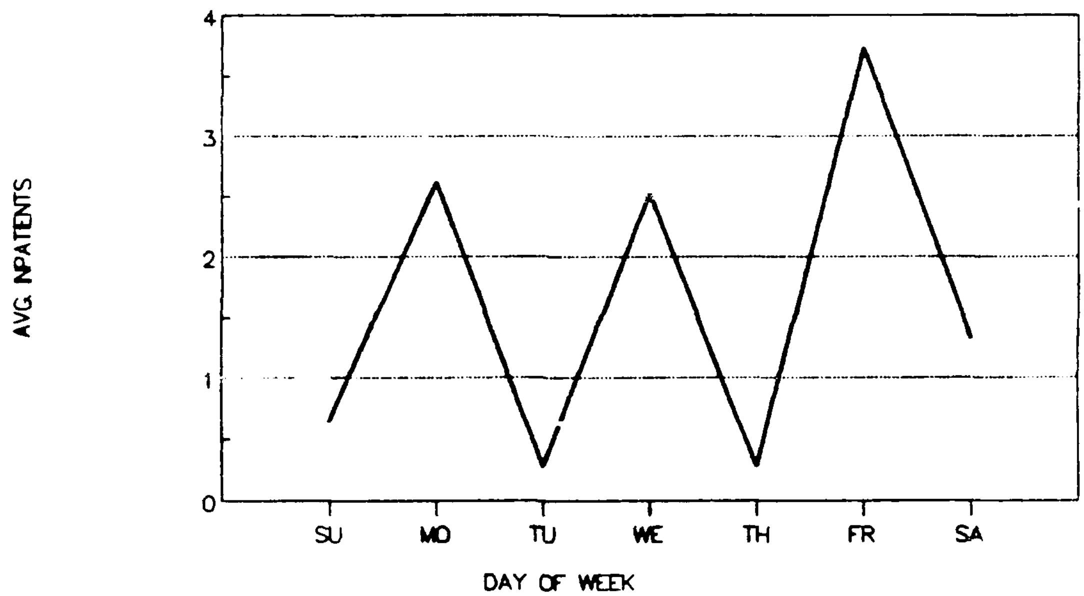


FIGURE 12: CENSUS - AERO EVAC ARRIVALS

159, were evenly distributed over Mondays, Wednesday, and Friday with about 53 arrivals each. A few times during the year two aircraft arrived in one day. Outside of those three days, Saturday most often had an Aero Evac aircraft arrival.

An Aero Evac aircraft arrival did not always mean inpatients would be arriving. Sometimes most or all passengers were outpatients. When inpatients were on board, 33 percent arrived on Friday. Another 46 percent arrived on either Monday or Wednesday. Saturdays averaged 12 percent of Aero Evac inpatient arrivals, and 10 percent arrived on either Sunday, Tuesday, or Thursday. The mean of Friday Aero Evac arrivals was 3.73 inpatients. Monday or Wednesday averaged 2.62 and 2.52 arrivals respectfully. Saturday and Sunday averaged 1.33 and .65 arrivals respectfully. Tuesday and Thursday averaged .27 arrivals each.

Aero Evac arrivals did not arrive according to an expected Poisson arrival process. Using the Chi Square test statistic, the null hypothesis for a Poisson distribution was rejected at all acceptable alpha levels and degrees of freedom = 6. This is because Aero Evacs are not random arrivals. Routine flights are scheduled by Aero Evac Headquarters at Scott Air Force Base, or Mondays, Wednesdays, and Fridays. WPMC is given short notice of an aircraft arrival and sometimes obtains a passenger listing, but rarely knows the number and type of patients on board. Thus the arrivals are treated as unscheduled.

Unscheduled. Emergency and Aero Evac arrivals were examined together as unscheduled arrivals (Table 17). The Aero Evac

TABLE 17 : CENSUS - UNSCHEDULED ARRIVALS

	SU	MO	TU	WE	TH	FR	SA
INPATIENTS	177	279	139	251	169	319	189
STD	2.44	3.07	1.77	2.81	2.55	3.49	2.49
MEAN	3.40	5.17	2.57	4.65	3.13	5.80	3.44

schedule still tended to force variations in arrivals with Monday, Wednesday and Fridays being high arrival days. Those three days averaged 5.17, 4.65, and 5.80 arrivals respectfully. Tuesday was the low arrival day of the week with an average arrival rate of 2.57 patients. If attempts were made to predict unscheduled arrivals, using the mean plus two standard deviations, a worst case prediction would be 12.7 unscheduled arrivals on Friday.

Scheduled. Scheduled arrivals totaled 5,697 patients and made up 79 percent of the data base (Table 18 and Figure 13). This large group of patients were scheduled and predictable. This fact contradicts the argument that arrivals are uncontrollable and overly complicate the scheduling of patients. This predictable number of patients could be increased to as much as 87 percent (8 percent Aero Evac plus 79 percent Scheduled) if specific information about Aero Evac arrivals were communicated to WPMC. In this analysis however, Aero Evac patients were analyzed separately from Scheduled patients.

While most unscheduled arrivals entered the hospital on Monday, Wednesday, or Friday (and are mostly Aero Evac on those days), most Scheduled patients arrived on Monday, Tuesday, and Wednesday. Over 57 percent of all Scheduled patients entered the

TABLE 18 : CENSUS - SCHEDULED ARRIVALS

	SU	MO	TU	WE	TH	FR	SA
INPATIENTS	768	1154	1093	1016	896	498	272
STD	7.39	6.85	5.11	4.45	5.74	3.66	4.39
MEAN	15.50	22.19	21.25	19.40	17.27	9.43	5.89

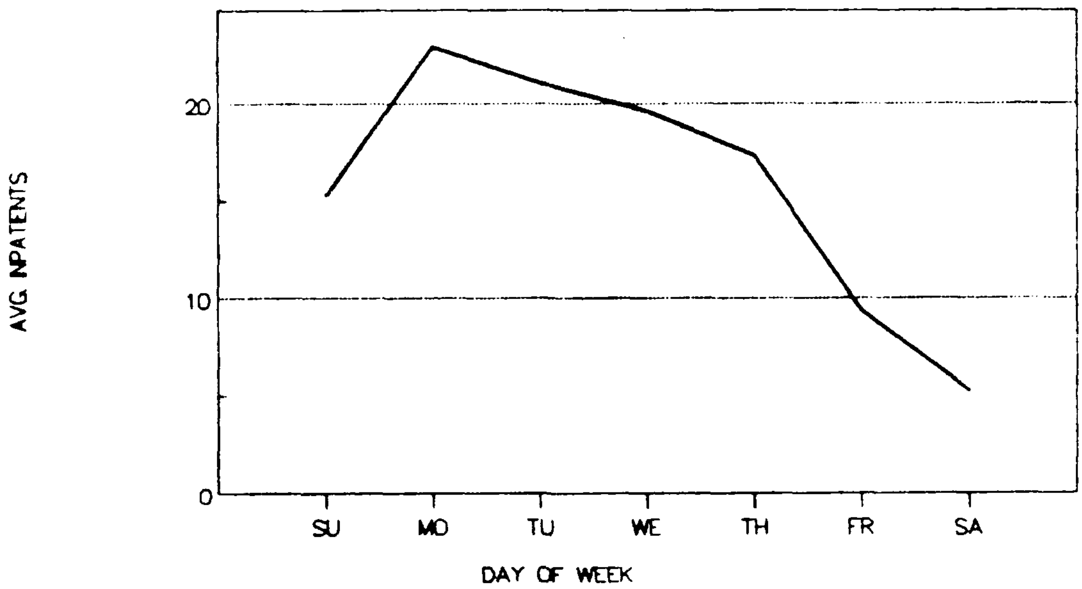


FIGURE 13: CENSUS - SCHEDULED ARRIVALS

hospital on the first three days of the week. The arrival mean for those three days was an average of 20.95 patients. Contrast that to the 43 percent who entered the hospital on Thursday through Sunday. Their average arrival rate was 12.02 patients per day.

Saturday was the least scheduled day with 5.89 patients entering the hospital on average. Monday was the highest day, with 22.19 patients on average followed predictably by Tuesday, Wednesday, and Thursday. The overall average number of patients scheduled was 15.47 patients per day.

<u>Total Arrivals</u> (Table 19 and Figure 14). Patient arrivals must also be considered as one entire group. It was reasoned unscheduled arrivals were such a small percentage of total

TABLE 19 : CENSUS - TOTAL ARRIVALS

	SU	MO	TU	WE	TH	FR	SA
INPATIENTS	945	1433	1232	1267	1065	817	461
STD	6.56	7.02	5.01	5.94	5.44	4.01	2.95
MEAN	18.70	28.13	23.69	24.37	20.48	15.42	8.90

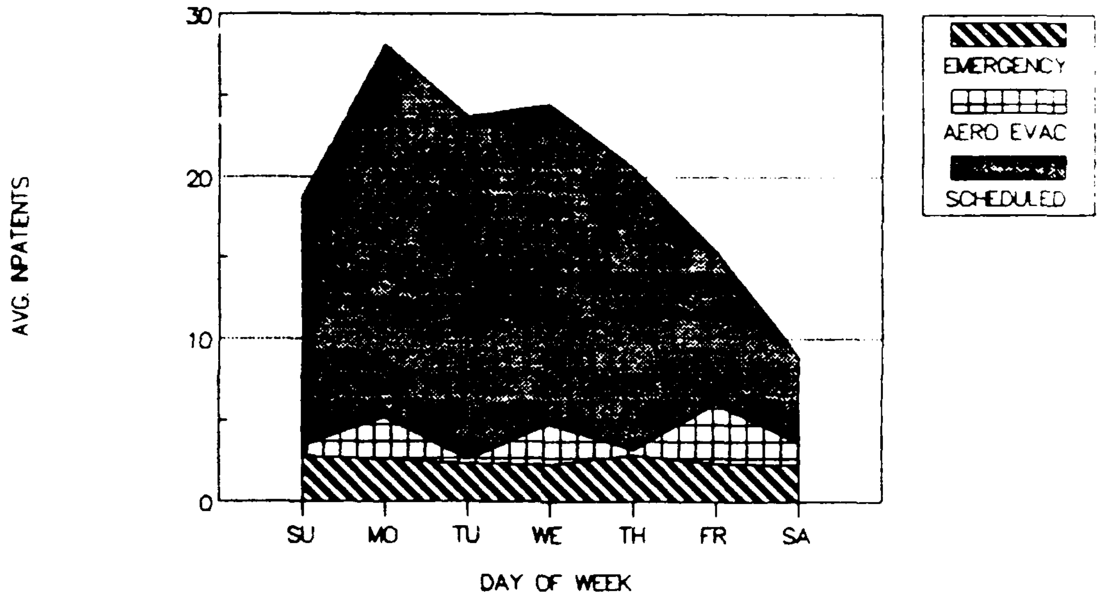


FIGURE 14: CENSUS - TOTAL ARRIVALS

arrivals, the Scheduled arrivals would absorb the fluctuation caused by unscheduled arrivals. Table 19 shows this reasoning is accurate. The total arrivals tended to follow the pattern of Scheduled arrivals as explained above.

Monday once again was the day most arrivals entered the hospital with an average of 28.13 followed in order by Tuesday, Wednesday, and Thursday. The mean arrival rate overall was 19.96 patients per day. A Wilk-Shapiro Rankit Plot test showed the arrivals for all days of the week were normally distributed.

Discussion Of Simulation Results

The results of the simulation were first discussed with key hospital staff members, and with Air Force Institute of Technology simulation instructors. First, the simulation results will be reviewed in general. Then the clinical specialties will be discussed in detail. In discussing the results, it is convenient to call the sum total of beds assigned to the clinical specialty "wards".

Two simulations were run. Sim1 modeled the Med Center as it currently operates and used historical arrival patterns. Sim2 also used historical data, but set the historical scheduled mean of the day of the week constant, and statistically modeled unscheduled Emergencies and Aero Evac arrivals. The hypothesis was if some of the randomness could be taken out of the arrival process, it would simulate a type of scheduling procedure and would enhance bed management.

The results of the simulation runs proved this hypothesis inconclusive. The only difference between the two runs was in how the beds ended up being distributed. Though some clinical services needed fewer beds, others needed more beds. Otherwise, the total number of beds hospital wide was exactly the same.

In the simulation, peak capacity never came within four beds of the 222 total. However, average occupancy was only 60 percent. The results of Sim1 showed three clinical specialties (wards) did not have enough beds, as patients were waiting several days for beds, and two clinical specialties (wards) had surplus capacity. When the beds were re-distributed in Sim1, average occupancy (excluding CCU) dropped from .59 to .55. Yet customer service was improved, in that all patients were given beds within the maximum time requirement.

Sim2 two also found some clinical specialties who did not have enough beds to meet their demand. For one ward, Sim2 suggested adding more beds where Sim1 had suggested excess capacity. The overall result was the same with both simulations suggested WPMC could operate at higher occupancy rates with four fewer beds than WPMC is currently operating at if current demand is equal to 1988 demand.

Occupancy is an important statistic when considering bed allocation. Should a ward that experiences 100 percent occupancy receive more beds than one with 85 percent occupancy? Not necessarily. Nearly every ward experienced 100 percent capacity at some time during the year. However, occupancy is based on the average number of patients in the ward, not the peak number. So hitting 100 percent capacity several times, such as Pediatrics did, is not as important as consistently hitting 71 percent as Medicine did.

As the results are discussed, the two simulations will be reviewed. Only the current and the optimum bed allocation will be considered for each simulation in this writing. Table 20 is a summary of the simulation results.

As results are discussed, keep in mind the simulation only simulated how beds are distributed--not how they were managed.

TABLE 2Ø : SUMMARY OF SIMULATION SOLUTIONS

Ward	Simulated Beds	Simulated Occupancy	Maximum Wait		Expected Occupancy
CCU					
-Current	7	.16	Ø	hrs	.1619
-Sim1	6	.19	Ø	hrs	
-Sim2	5	.22	Ø	hrs	
GYN					
-Current	11	.55	1 day 4	hrs	.6222
-Sim1	14	.43	1.6	hrs	
-Sim2	14	.45	3.2	hrs	
OB					
-Current	18	.65	1 day 3.2	hrs	.6292
-Sim1	22	.53	2.4	hrs	
-Sim2	24	.5Ø	.8	hrs	
Ortho					
-Current	16*	.85	6	days	.7955
-Sim1	27	.59	Ø	hrs	
-Sim2	23	.59	Ø	hrs	
Medicine					
-Current	51	.71	Ø	hrs	.6697
-Sim1	5Ø	.73	3.2	hrs	
-Sim2	5Ø	.74	1.6	hrs	
MenHealth					
-Current	55	.5Ø	Ø	hrs	.4735
-Sim1	41	.67	Ø	hrs	
-Sim2	36	.74	Ø	hrs	
Pediatrics					
-Current	7*	.26	.8	hrs	.2732
-Sim1	7	.26	.8	hrs	
-Sim2	8	.27	1.6	hrs	
Surgery					
-Current	57	.62	Ø	hrs	.6Ø22
-Sim1	51	.7Ø	3.2	hrs	
-Sim2	58	.61	3.2	hrs	

* Beds shown are reduced 25% to correct for 3 month ward closure

Expected Occupancy = Avg LOS * Arrivals (Table 3)/ Beds * 365

Conclusion: Using 1988 demands, fewer beds are necessary to meet demand. Occupancy is an average of .58Ø8 expected (excluding CCU), .59 for Sim1, and .55 for Sim2.

The simulation did not allow bed borrowing, but still used all of a clinical specialty's arrivals in that clinical specialty's allocated beds. Perhaps the clinical specialty had previously borrowed beds during peak demands. By putting the "no borrowing" constraint upon the clinical specialties, occupancy is affected. Peak demands can only be solved in the simulation by re-allocating beds for the entire "year" and this decreases occupancy levels in some wards.

Therefore, keep in mind the goal of the simulation was to decrease waiting times. The results discussed here suggest optimum performance for that goal. But the results are not necessarily optimum for occupancy or other goals. Also these are preliminary results based on a point estimate versus a confidence interval.

Simply because a clinical specialty has extra bed capacity does not mean the beds are being mismanaged. There may be legitimate reasons behind a style of management that explain how beds in a particular ward are handled. Some possible reasons will be considered.

The length of stay used in the simulation, includes a set time of one hour to prepare the bed for the next patient.

CCU. The ward with the lowest occupancy rate was CCU. Beginning with the current seven beds and an average length of stay of 2.87 days, the occupancy was 16 percent. To determine the optimum number of beds for the CCU ward, a wait time for beds of zero was used.

Sim1 generated 142 CCU patients. The maximum number in the queue with seven beds in the ward was four patients. Though four patients arrived at the same time, beds were available and no one was required to wait for a bed. The average number of patients in the ward was 1.109 with a standard deviation of 1.006 ranging between 0 and 6 patients in the ward. Patients stayed in the ward an average of 2.810 days. The standard deviation on the length of stay was 3.186 with a maximum stay of 24.1 days.

The solution of the simulation was to free up one bed, allocating six beds to the ward. The effect was that occupancy rose to 19 percent and all others factors stayed nearly the same.

Sim2 generated 143 patients. The solution for Sim2 was to free up two beds. Though the number of arrivals was one more than in Sim1, when beds were reduced to five, the results were nearly the same as Sim1's six bed solution. With five beds set in Sim2, the queue had a maximum of four patients who received beds immediately. The average number in the ward was slightly higher than Sim1, 1.117 with a standard deviation of 1.103. The solution for simulation two generated an occupancy of 22 percent.

CCU may want to carry the extra bed(s) as safety stock for surges in arrivals. CCU patients are such high risk patients, that economies gained from reducing beds in CCU must be weighed carefully against the risk of loss of life.

Judy Faulkner, a nurse at Dayton's Miami Valley Emergency Trauma Center, was surprised at the simulation results for the CCU ward (Faulkner:1989). The average length of stay seemed short. Her call to Mary Lou Anderson, Director of Operations Research, Miami Valley hospital confirmed the length of stay at Miami Valley's CCU is higher than WPMC. Miami Valley has 28 beds and an average stay of four days.

Colonel McDonald (1989), Chairman of the Medicine Department, has an interest in the CCU since all of the CCU patients are from Medicine specialties. Since one comment on the survey complained of needing more nurses in the CCU, yet the simulation suggested that there were enough, he thought the nurse staffing of the ward should be reexamined.

While it is highly unlikely CCU patients could ever be scheduled as Sim2 attempts, the results show the possibilities of the concept. Beds might be reduced while customer service stays high and occupancy increases.

GYN. The GYN clinical service started with 11 beds and an occupancy of 55 percent. Both Sim1 and Sim2 suggested re-allocating three beds to GYN, lowering the occupancy to about 46 percent.

Sim1 generated 501 Gynecology patients. The maximum number in the queue with 11 beds in the ward was five patients. They waited an average of 12 minutes for a bed and a maximum of 1.5 days for a bed. The average number of patients in the ward was 6.021 with a standard deviation of 2.427 ranging between 0 and 11 patients in the ward. Patients stayed in the ward an average of 4.358 days. The standard deviation on the length of stay was 4.063 with a maximum stay of 24.2 days.

The solution of Siml was to reallocate three more beds to GYN, raising the total beds assigned the clinical specialty to 14. The effect was occupancy dropped to 43 percent and the maximum wait for a bed was 1.6 hours.

Sim2 generated 535 patients. The solution for Sim2 was also to reallocate three more beds to GYN raising the total beds to 14. Even though 32 more patients arrived, the queue had a maximum of six patients, compared to Siml's five patients, who waited a maximum of 3.2 hours for a bed. The average number in the ward was slightly higher, 6.276 with a standard deviation of 2.680. The average occupancy was 45 percent.

OB. Like GYN, OB required four more beds to reduce the line of waiting patients. The ward currently has 18 beds with an occupancy of 65 percent. Siml suggested reallocating four beds to OB to correct for waiting patients, and Sim2 suggested adding six beds. One might expect that OB would need a waiting time of 0 since birth cannot be delayed. However, since OB patients first go into a Labor and Delivery room, they do not need a bed on the ward immediately. Therefore, they were allowed the same "wait time" as other specialties.

Siml generated 1156 labor and delivery patients. The maximum number in the queue with 18 beds in the ward was 11 patients. They waited an average of 27 minutes for a bed and a maximum of 1.8 days for a bed. The average number of patients in the ward was 11.679 with a standard deviation of 3.710 ranging between one and 18 patients in the ward. Patients stayed in the ward an average of 3.678 days. The standard deviation on the length of stay was 3.667 days with a maximum stay of 28.8 days.

The solution of the Siml was to reallocate four beds to OB. The result was occupancy dropped to 53 percent, maximum waits dropped to 2.4 hours and all others factors stayed nearly the same.

Sim2 generated 1188 patients. The solution for Sim2 was to reallocate six more beds to OB. This dropped wait times to 48 minutes maximum and raised occupancy to 50 percent over Sim2's base run. The only thing improved over Siml was the time patients waited for beds.

Lieutenant Drake, a nurse in Labor and Delivery, was called to get his perspective on the OB simulation results (Drake, 1989). He said that as soon as a patient enters the Labor Room, and it is clear she's going into labor, a bed, if available, is reserved for her on the OB ward. He also noted that often OB beds are all occupied. Just two days prior to the interview, OB beds were full. Several times he's seen the OB ward go from seven patients to full in a 24-hour period.

When that happens there are several places to find a bed. One way is to borrow a bed from another ward. Sometimes a mother is in the hospital, fully recovered, waiting for her newborn baby to be released. She doesn't need specialized nursing care anymore so the OB personnel try to borrow a bed from another ward and transfer her.

Another place is in the Labor and Delivery area. Patients can be held in the Labor and Delivery area until OB has an opening. Drake said that while the OB ward has 18 beds, the Labor and Delivery rooms have another 7. Five are for labor and two are for recovery. He's seen patients held in Labor and Delivery rooms for up to eight hours. However, even using Labor and Delivery beds does not always provide enough beds.

A third place to find beds, is in the hall. Drake noted that once in 1988 when the OB ward was full, all seven beds in L&D were full and another patient was on a bed in the hallway.

Orthopedics. One of two clinical specialties who had their clinic shut down for three months in 1988 was Orthopedics. Beds were reduced in the simulation to account for the reduced demand. Beds were reduced 25 percent from 21 to 16 and the 3/4 year demand evened out for the year. The assumption was that the reduced demand coupled with reduced supply, will generate numbers similar to the fully operational year. The reader might mentally reallocate five to any numbers discussed here to correct the ward to current bed levels. Both simulations showed a need for Orthopedics to increase the number of beds they used.

Siml generated 666 Orthopedic patients. The maximum number in the queue with 16 beds in the ward was 15 patients. They waited an average of 6.6 hours for a bed and a maximum of 6.0 days for a bed. The average number of patients in the ward was 13.572 with a standard deviation of 2.611 ranging between six and 16 patients in the ward. Patients stayed in the ward an average of 7.367 days. The standard deviation on the length of stay was 6.87 with a maximum stay of 51.3 days. The occupancy was 85 percent.

The solution of the Siml was to increase beds by reallocating 11 for a total of 27. The impact was occupancy dropped to 59 percent, the maximum number in the ward queue dropped from 15 to 7, and patients waited an insignificant amount of time for a bed. A total bed allocation of 26 caused excessive waiting.

Sim2 generated was 682 patients. The solution for Sim2 was also to reallocate beds, though only 7. Reallocating seven beds gave nearly the same results as the solution for Siml. The occupancy of Sim2 was 59 percent, or a little higher than Siml's optimum solution. The number in the bed queue dropped to seven, and there was no significant time spent waiting in the queue for a bed.

Medicine. The clinical specialty that appeared to be the most efficiently managed was Medicine. In the base run, the ward had 51 beds and the highest occupancy of any ward simulated. The average occupancy was 71 percent. There were no patients waiting for beds longer than was determined as acceptable. The only improvement Siml suggested over the base run of 51 beds was to either release one bed, bringing the occupancy up to 73 percent, or schedule more patients.

Siml generated 1856 Medicine patients. The maximum number in the queue with 51 beds in the ward was 15 patients. They waited a maximum of 3.2 hours for a bed. The average number of patients in the ward was 36.362 with a standard deviation of 5.001 ranging between 20 and 50 patients in the ward. Patients stayed in the ward an average of 7.063 days. The standard deviation on the length of stay was 7.070 with a maximum stay of 55.5 days.

The solution of Sim1 was to free up one bed, allocating only 50 beds to the ward. The effect was occupancy rose to 73 percent and all other factors stayed nearly the same.

Sim2 generated 1885 patients. The solution for Sim2 was also 50 beds. Even though thirty more patients arrived, the queue had a maximum of 13 patients who waited a maximum of 1.6 hours for a bed. The average number in the ward was slightly higher, 36.904 with a standard deviation of 5.848, and a higher minimum number in the ward of 22 patients.

Colonel McDonald discussed these results (McDonald, 1989) stating that occupancy needed to be further improved for his clinical specialty. He noted that just because his clinical service had no patients waiting did not mean patients didn't need hospital services. It simply showed his successful attempt to make demand equal supply. In fact, he thought if beds were re-allocated, patients would materialize to use the extra supply.

Colonel Tuttle called this type of patient a ghost patient (Tuttle, 1988). A ghost patient is someone who is receiving medical services somewhere else, but would return to the Medical Center if customer service were better. Colonel Tuttle thought there were an indeterminate number of people who were frustrated with the military system. They might use civilian services through Champus or by paying for it on their own. If hospital customer service could be improved, the hospital might suddenly find a surge of patients never seen before.

Mental Health. One perplexing clinical specialty was Mental Health. Both substance abuse and psychiatric care were modeled together. One reason for this was neither demonstrated a solid pattern of arrivals when considered by themselves. However, they didn't demonstrate a solid pattern of arrivals when combined either. In the end, it was decided to put them together because it simplified the simulation process. Overall, the simulation results suggested Mental Health had as many as 19 beds of extra capacity.

Siml generated 319 Mental Health patients. The maximum number in the queue with 55 beds in the ward was 5 patients. The occupancy was 50 percent. Patients did not wait for a bed at all. The average number of patients in the ward was 27.463 with a standard deviation of 5.484; the number of patients ranged ranging between 17 and 41 patients in the ward over the year. Patients stayed in the ward an average of 30.446 days. The standard deviation on the length of stay was 28.725 with a maximum stay of 158.9 days.

The solution of Siml was to reduce capacity to 41 beds. This reduction raised occupancy to 67 percent. Otherwise the picture looked similar to the 55-bed simulation.

Sim2 generated 315 patients. The solution for Sim2 was also to reduce beds, this time to 36. Even though a similar number of patients arrived, the queue had a maximum of four patients who did not wait for a bed. The average number in the ward of 26.564 was slightly less than Sim1 with a range between 10 and 36 patients.

There may be several reasons why both simulations suggested a significant reduction in beds. One reason may the type of arrivals that come into Mental Health. Typically Mental Health gets a significant influx of patients on Monday, Wednesday, and Friday when the Aero Evac aircraft arrives. However. peaks and valleys of individual wards were not be simulated. In this regard, Sim1 may have smoothed Mental Health arrivals, from three days to seven, and Sim2 may have smoothed them even more by removing randomness.

Another reason both simulations suggested reducing Mental Healths beds could be because Mental Health had a reduction in patients in 1988, but the simulation did not correct for that probability. Most of Mental Health's patients come through the Aero Evac system, and Aero Evac arrivals were reduced in the late spring/early summer. There was no way to determine the effect of a reduced Aero Evac schedule on any individual ward. Nevertheless, Mental Health results might have been distorted by using current bed allocations and past demand.

Still another reason both simulations suggest a reduction in Mental Health beds could be because excessive length of stays were removed as statistical outliers. Length of stays as long as 174 days were removed to allow for modeling. In reality those patients use beds, but in a simulation the long length of stay of several patients would skew the mean length of stay for the ward. Keeping in the outliers would cause average length of stay for the ward to be higher and not model reality.

Pediatrics. The Pediatrics clinical specialty was one of the few specialties with few enough arrivals it could be examined thoroughly. Pediatrics, like Orthopedics, was closed for three months in 1988. Like Orthopedics, for the purpose of simulation, beds were reduced 25 percent to compare to the demand of the year. The results of the simulations suggested Pediatrics is using several of their beds just to meet peak demands for beds, causing low occupancy.

Sim1 generated 212 Pediatric patients. The maximum number in the queue with seven beds in the ward was three patients. At least one person waited for a bed a maximum of 48 minutes. The average number of patients in the ward was 1.846 with a standard deviation of 1.457 ranging between 0 and 7 patients in the ward. Patients stayed in the ward an average of 3.168 days. The standard deviation on the length of stay was 3.045 with a maximum stay of 16.8 days with an occupancy of 26 percent. The solution of the Sim1 was to keep beds as they are.

Sim2 generated 240 patients. The solution for Sim2 was to reallocate one bed making total beds equal to eight. The queue had a maximum of four patients who waited a maximum of 1.6 hours for a bed. The average number in the ward was slightly higher, 2.133 with a standard deviation of 1.146 and a slightly higher occupancy of 27 percent.

Low occupancy is a concern when looking at Pediatrics. Are Pediatric arrivals so random and erratic that extra beds are needed to accommodate the demand? Is any type of scheduling being done? Why do some clinical specialties, such as Medicine, that handle almost six times as many beds as Pediatrics, maintain an occupancy rate 45 percent higher than Pediatrics? Of all the clinical specialties, Pediatrics appears to be the one deserving the most attention for its occupancy level.

Surgery. Surgery, the clinical specialty that generated the largest number of patients in 1988, also controlled the largest number of beds. The two simulation results were contradictory. One suggested Surgery had an extra capacity of six beds, and the other suggested Surgery needed to add one more bed.

Siml generated 2218 Surgery patients. The maximum number in the queue with 57 beds in the ward was 16 patients. The patients had no significant wait for beds. The average number of patients in the ward was 35.553 with a standard deviation of 6.354 ranging between 16 and 55 patients in the ward. Patients stayed in the ward an average of 5.819 days. The standard deviation on the length of stay was 5.833 with a maximum stay of 52.9 days. Occupancy was 62 percent.

The solution of Sim1 was to reduce the total number of Surgery beds by six beds to 51. The result was occupancy rose to 70 percent. All other factors stayed nearly the same except the maximum wait for a bed rose to 3.2 hours.

Sim2 generated 2226 patients. The solution for Sim2 was the opposite of Sim1. Sim2 suggested reallocating one bed bringing the total Surgery beds to 58. With this change, the queue had a maximum of 13 patients who waited a maximum of 3.2 hours for a bed. The average number in the ward was slightly higher, 35.603 with a standard deviation of 6.271, and a higher minimum number In the ward of 19 patients and the maximum was 58 patients. The occupancy was 61 percent.

Clearly, in this instance, operating under the conditions of Sim1 was preferable to Sim2. Sim1 used fewer beds and had a higher occupancy rate. However, consideration must be given to the one 365 day run, accomplished here, which generated a point estimate versus multiple runs of years, that give a confidence interval.

How Many Beds Are Needed?

Chapter Two established a framework to answer this question. The literature noted occupancy level is the average bed use of all beds in a hospital. The average occupancy rate in the US, not including nursery beds, is between 73.4 percentage (Hancock et al., 1978:25) and 76 percent occupancy (Phillip et al., 1984:53).

Martin's Formula. Table 21 was created from WPMC information by using Martin's formula (page 25) to determine occupancy and required beds (Martin et al., 1985:63). It shows the relationship between occupancy and required beds. Column one represents the occupancy level. Columns two through nine show the number of beds required by clinical specialty to meet the occupancy level in column one using the clinical specialty's specific average length of stay. Column ten is a summation of all the clinical specialty's beds. Column eleven is the number

TABLE 21 : DETERMINING ACUTE CARE BEDS NEEDED

OCCUP LEVEL	MED AA_	OB ACA	SUR AB_	ORTH AE_	M-H AF_	GYN ACB	CCU ABG	PED ADA	TOTAL *	#
Less					$55		$7	$9		
0.50	68	23	69	25	50	$11	2	4	252	299
0.55	62	21	62	23	46	10	2	3	$229	272
0.60	57	19	$57	21	42	9	2	3	210	249
0.65	53	$17	53	$20	39	8	2	3	194	$230
0.70	$49	16	49	18	36	8	2	3	180	214
0.75	46	15	46	17	34	7	2	3	168	199
0.80	43	14	43	16	31	7	1	2	158	187
0.85	40	13	40	15	30	6	1	2	148	176
0.90	38	13	38	14	28	6	1	2	140	166
0.95	36	12	36	13	27	6	1	2	133	157
1.00	34	11	34	13	25	5	1	2	126	149

Length of stay per ward

	MED	OB	SUR	ORTH	M-H	GYN	CCU	PED
AVG	6.82	3.53	5.77	7.08	29.13	3.96	2.87	3.24
STD	6.63	2.35	6.76	4.00	23.24	1.49	1.77	2.01

Average length of stay of hospital = 7.80

* Bed total determined by adding up service specialty totals.
# Bed total determined by using one average LOS = 7.80. This is the method Martin et al. proposed (Martin et al., 1985:63).
$ Currently number of beds assigned, sum = 225

of beds required by the hospital to meet the occupancy level in column one using the hospital's average length of stay.

Four pieces of information can be obtained from the Table: The desired occupancy; The exact number of beds needed per ward based on clinical specialty's individual length of stay and desired occupancy; The summation of the individual beds; and The exact number of beds needed for the hospital based on the patient's average length of stay and desired occupancy.

The Table can also be read in reverse to determine the average occupancy of the last year. If the current number of adult beds (229) is looked at in the total column, and followed to the left to intersect the occupancy column, the average occupancy of 1988 would be about between 55 (*) and 65 (#) percent depending on which total column was used.

Occupancy Differences

Though Table 21 estimates the average occupancy of the Medical Center 1988 to be as high as 65 percent, hospital personnel have estimated much higher levels. Wong calculated occupancy levels above 75 percent (Wong, February 1988; March 1988). Another experienced staff member, who asked to remain anonymous estimated the hospital operates at approximately 80 percent occupancy. The simulation results in this chapter support and confirm the low occupancy calculated in Table 21. The simulation found an average occupancy in each ward in 1988 between 16 percent (CCU) and 85 percent (Orthopedics). The average occupancy of the hospital according to the simulation was only about 59 percent.

This discrepancy between hospital personnel perception and calculated figures could be due to errors in the simulation or calculation errors by hospital personnel. It might also be due to a bias by the hospital staff. They know hospitals commonly have occupancies of 75 percent and more. Since they may see a problem with bed management, a logical conclusion would be the hospital is experiencing a high occupancy and needs to add more beds. Or perhaps the staff members, at times, have seen beds in their respective wards full and generalized the spot high occupancy to the hospital. The simulation did show fluctuation. All wards except for the Mental Health ward reached 100 percent occupancy at least one time.

This discrepancy in hospital personnel perception and calculated figures could also be due to hospital construction that caused both demand and supply of beds to fluctuate. Between approximately April 18 and July 25, two wings of the hospital were closed for construction. Orthopedic patients were sent to Wurtsmith Air Force Base, Mich, and Pediatric patients were sent off base. Aero Evac patients were reduced between 1 April and 30 June (Wong, April 88).

The change in capacity meant the number of beds fluctuated, and was often less than 229. This means an overall occupancy rate for the hospital cannot be determined accurately without an exact bed count for each day of the year. It does appear WPMC never reduced beds more than 50 to a low of 180 beds during the wing closures. Assuming 180 beds was the constant beds available for the entire year Martin et al.'s formula would still suggest a maximum average occupancy rate of 82 percent. It seems logical to conclude Wright-Patterson Medical Center operated during the year between an occupancy of 60 percent (the simulation average) and 82 percent (high from Table 21 for 180 beds).

Table 21's information is also useful for planning. Individual wards can be evaluated to determine how many beds they need based on last year's demand. However, it is important to note Pediatric and Orthopedic services are not accurately represented during the April to July time frame. They must be evaluated on the nine months they were actually serving patients rather than the entire year.

Determining Mental Health's bed needs separately shows the effect a long length of stay has on bed numbers. Though Mental Health patients represent 4.5 percent of the patient population, they occupy approximately 31 percent of the beds (and would occupy even more with outliers averaged in to the length of stay).

Keep in mind Martin et al.'s acute bed prediction formula does not require a hospital to separate services, but to use a hospital average. If a hospital average was used, the total patient population would be 6995 and the average length of stay would be 7.80 and the required beds would be 187. The number of beds recommended by the formula, 187 is 31 fewer than the simulation suggested, and 42 fewer than the 229 currently used. Not only did Martin et al.'s formula suggest low occupancy rates for WPMC, but the simulation results also did. Hancock said that many hospitals with 300 beds, could operate in excess of 97 percent occupancy. They do not operate at that high level because they simply allow too many beds and do not use an admissions scheduling system (Strande et al. 1978:250; Hancock 1978:65).

Wong's Occupancy Estimate. Table 22 shows how occupancy is affected by how it is computed. Table 22 shows in late 1987 and early 1988 Wong computed occupancies between 58 percent and 101 percent depending on the time frame and configuration of the

TABLE 22 : WONG'S OCCUPANCY FINDINGS

A	B	C	D	E
MONTH	ADULT BEDS	FUNCTIONAL ADULT BEDS	FUNCTIONAL ADULT BEDS SU - TH	HIGHEST DAY OF FUNCTIONAL ADULT BEDS
Beds	232	177	177	177
November	NA	74.6%	78.0%	82.6%
December	58.0%	64.5%	66.6%	85.3%
January	72.0%	77.4%	85.6%	101.0%
February	71.0%	78.0%	83.0%	NA

Adult beds = 255 total beds less 23 cribs and bassinets = 232
Functional adult beds = 232 adult beds less 50 VA (Mental Health) less five Same Day Surgery beds = 177.

Wong determined occupancy by taking number of beds occupied from the AQCESS report +6 OB contingency beds +3 beds that are the average daily blocked beds, and dividing it by number of beds the column represents.

(Wong, February 88; March 88)

hospital beds. Wong said in January of 1988, the hospital occupancy averaged 72.0 percent--unless Mental Health and Same Day Surgery beds were removed. When those beds were removed the occupancy was 77.4 percent. However, when examining only Sunday through Thursday, the occupancy was 85.6 percent. And if the highest day of the month was singled out, the occupancy for that day was 101.0 percent (Wong, February 88)!

Wong showed that at times there was high occupancy. Nevertheless, the main point her work demonstrates is that WPMC has an erratic occupancy rate. At the beginning of the week occupancies were high, but when averaged out over the entire week, the occupancy rates they are much lower.

It does little good for a hospital to take use occasional peak occupancies as indicators of efficiency. All a peak high occupancy means is that sometimes resources are being used efficiently. But at other times, those same resources remain idle. Idle resources are an extremely visible sign of waste. They waste overhead such as support manpower or physical structures, and defeat the purpose for which they were intended. A consistent occupancy level demonstrates efficient management. A resource can only generate "profits" (healthy patients) if it is active. Thus active resources are a visible sign a hospital is accomplishing its purpose. Of course, some beds need to be idle to meet the demands of Emergency patients, so extremely high occupancy levels may not be desirable. However, idle resources guarantee waste, while active resources give the hope of a "profit", which in the case of a military hospital is customer service.

Wellbrock's Occupancy Estimate. To get a definitive figure on 1988 occupancy rates, Mr. John Wellbrock, Chief, Data Management WPMC was interviewed (Wellbrock, 1989) (Figure 15). He could not provide an answer because the information needed to make such a calculation was not available. Several times he said it was difficult to determine occupancy, but was finally able to give a best guess of a monthly occupancy for 1988.

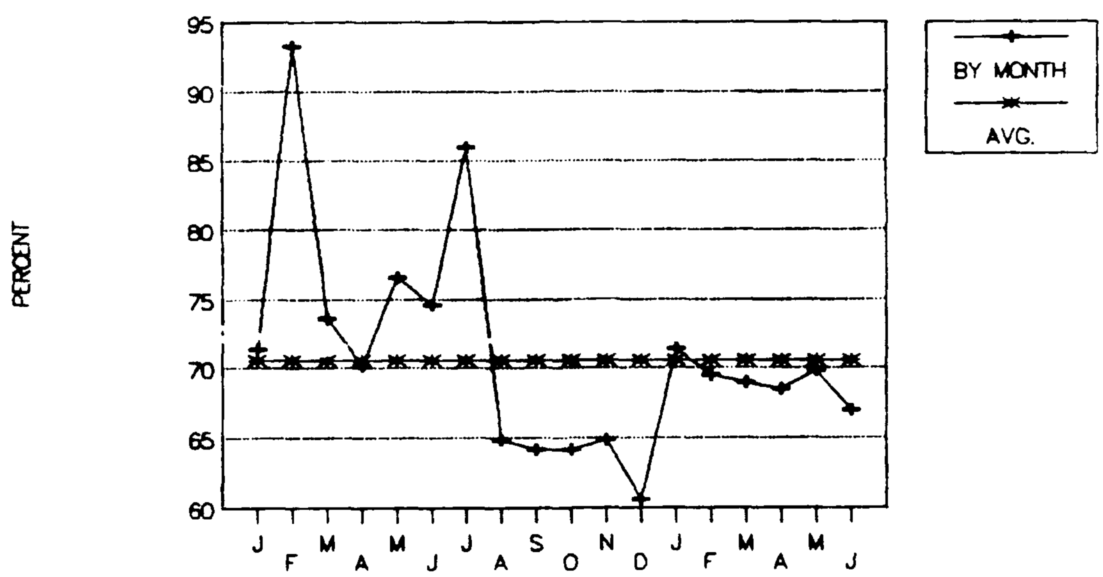


FIGURE 15: WELLBROCK'S OCCUPANCY FINDINGS

Mr. Wellbrock first said occupancy depended on how beds were defined. Once beds were defined as those being staffed, he wanted to know the number of beds to use. It seems that while the number of total patient days (total patients * time period) are kept by the hospital, total possible bed days (total available beds * time period) are not. Number of available beds are not kept past 90 days. He decided to divide the year up into two sections due to hospital construction. From January until July of 1988, Wellbrock based his best guess on the bed levels stated in the Phased Construction report (WPMC, November 1987). From August 1988 until June 1989 he used the current number of beds available of 229 beds.

Wellbrock's calculations showed that during the time between January 1988 and June 1989 occupancy ranged from a high in February 1988 of 93.3 percent to a low in December 1988 of 60.5 percent. The average occupancy was slightly higher than 70 percent. His findings place occupancy somewhere between the simulation's estimation and Wong's estimation. If Wellbrock's finding are accurate, then WPMC operated below national averages.

Summary

Chapter IV provided a detailed presentation of interview findings, results of the questionnaire, and results of the simulation. Chapter V will condense this information in major findings and recommend actions.

V. Conclusions And Recommendations

The general research question asked in Chapter One was "What can be done to improve bed management at WPMC?" This chapter highlights the conclusions based on the significant findings of the thesis research and recommendations to improve bed management.

Research Conclusions

1. **The process of admissions and dispositions itself as well as using the Same Day Surgery Unit are working well.** WPMC has given a lot of thought to improving the admission process. Having preadmit surgery patients do lab and paper work prior to ward entry are an efficient use of the hospital's resources. The Same Day Surgery Unit has eased the burden on inpatient wards by allowing those patients to go home rather than taking up a ward bed. Some hospital staff members have complained that at times Same Day Surgery Unit patients need inpatient care. Others say sometimes the combination of preadmitted patients versus same day surgery patients has made scheduling the OR difficult. Nevertheless, both processes represent good attempts at correcting bed management.

2. **Currently, the Admissions and Dispositions Office uses a First Come, First Serve scheduling procedure to match patients to beds.** This technique appears inadequate for planning. Currently, the patient waits until the day of admissions, to be assigned a

bed. It is not possible to guarantee a patient a bed more than a few hours prior to his entry into the hospital. Capt Meccia, Chief of A&D, says there are too many changes to assign bed in advance. Therefore, A&D does not attempt to schedule. They simply wait to see who shows up and hope there will be a bed for the patient. The consequences are patients face the possibility of being sent home.

3. **There appears to be a lack of planning rather than a lack of beds.** A scheduling procedure is virtually nonexistent. One administrator said he scheduled one patient a day. Most hospital staff are just to busy to find the time to address the problem or appear immobilized at the complexity of scheduling. The root cause of the problem is a lack of information on which to take action. Since clinical specialties do not understand the processes affecting them, such as Emergency arrivals, they can not determine schedules or length of stays or departures. They are not able to schedule.

4. **Conflict and confusion exist over who is the primary manager of beds.** Physicians schedule patients and indirectly beds, but A&D must find a bed for the patient the physician scheduled. If a bed can't be found the physician may become involved along with ward bed coordinators and the nurse bed coordinator. Physicians don't want the responsibility, yet A&D does not have complete authority in the role of bed manager either.

The lack of a single bed manager results in information choke points where information fails to be relayed. The A&D office has little authority in handling beds. Physician's time is spent on the administrative task of finding a bed which interferes with caring for patients. Patients anxiously wait for a bed. Thus, all those involved with the process, are poorly served by lack of a primary manger of beds.

5. **There is a lack of communication between clinical specialties and A&D, between wards and A&D, between one clinical specialty and another, and between the hospital and the patient.**

The clinical specialties who represent the physician, and A&D are not coordinating. Clinical specialties schedule patients without consulting with A&D concerning bed availability. In spite of the lack of a "reservation," A&D is responsible for finding the bed when the patient arrives.

Wards and A&D do not communicate either. Ward nurses often do not notify A&D when a bed is being vacated. A&D may find out when the patient shows up. This communication problem prevents A&D from preparing ward arrivals in advance. Though A&D is able to respond quickly and assign a new patient to the bed, the communication problems could possibly cause A&D to send a patient home unnecessarily.

Clinical specialties do not communicate well among themselves either. Complaints about bed allocations are common. Inter-specialty rivalry is demonstrated in complaints about bed sharing. Specialty-centered rather than patient-centered thinking seems to be common.

There is also a lack of communication between the hospital and the patient. Patients do not know for certain they will be admitted. They don't always know what to do with their luggage prior to admittance. It is unclear to the patient what time admittance takes place: it in the morning when he shows up, or afternoon when he gets a bed? On the other end of their hospital visit, patients do not know for sure when they will be released, because physicians are not sure and thus can't communicate a definite release time to the patient. The lack of communication creates unnecessary instability and anxiety in the patient.

Each element of the hospital appears to be working their own problems with a micro view of the hospital rather than a macro view. They may see themselves as an entity rather than part of a system. They may be concerned about customer service on their ward, but they do not seem to view overall customer service to all patients as important.

6. **In general, most staff members believe there is a bed management problem.** On the survey, most staff members indicated multiple factors that make bed management more difficult. Also, all hospital staff interviewed believed there was a problem although the interviewees had different and often complex reasons as to why the problem exists.

7. **The WPMC staff believes factors causing the bed management problem are: 1) the staff to bed ratio, 2) not enough**

beds and, 3) the unpredictability of unscheduled arrivals. While there were significant differences on certain variables, on these three factors, there was strong agreement.

8. **Among the WPMC staff there is both general apathy about the problem, and some serious interest.** Comments made to the researcher ranged from a hopeless, "You are not going to solve the problem", to an excited, "Do you think this simulation could be used to predict available beds?" Some people had no idea how to solve the problem and others were very specific. They suggested developing a predictive model or giving more beds to a certain clinical specialty.

9. **Arrivals came from Emergency, Aero Evac, Scheduled, and the Same Day Surgery Unit.** Emergency arrivals accounted for 13 percent of arrivals and averaged about 2.5 inpatients a day with Sunday being the peak day with 2.75 average arrivals.

Aero Evac patients accounted for 8 percent of inpatients. Aero Evac aircraft averaged one aircraft arrival every Monday, Wednesday and Friday. About 50 percent of the time an Aero Evac aircraft arrived on Saturday. Those aircraft carried an average of slightly less than three patients on Monday and Tuesday, and slightly less than four on Fridays. On Saturdays Aero Evac aircraft carried an average of 1.33 patients.

Scheduled arrivals accounted for 79 percent of inpatients. Most patients were scheduled to be admitted on Monday at an average of 22.19 inpatients. There was a continuous drop off until Saturday, with an average of 5.89 Scheduled arrivals. There was an increase in Scheduled arrivals on Sunday.

Same Day Surgery had little impact upon bed management. Once in a while a patient expected to go to home quarters, instead needed to remain at the hospital. The number of times this occurred is unclear.

When all arrivals were considered as a whole, Mondays were by far the heaviest arrival day with an average of 28.13 patients. There was a decrease through the week that reflected the impact of Scheduled arrivals. Saturday was the lowest day of the week with an average of 8.90 inpatients.

10. Percent of arrivals and length of stay depends greatly on the clinical specialty. Surgery received 31 percent of the inpatients followed by Medicine at about 17 percent. All others were less with the lowest being the Critical Care Ward which received only 2 percent of arrivals.

Length of stay averaged 7.80 days hospital-wide. The most noticeable difference was in Mental Health, with an average length of stay of 30.13 days, with individual stays as high as 174 days. On the other end of the scale was the Critical Care Ward averaging 2.87 days.

11. **The hypothesis that a scheduling system using the number scheduled equal to the current daily scheduled means, was inconclusive.** A scheduling system that simply uses an average historical mean, by day of week, as a goal, as Sim2 did, may or may not help all wards. Certain clinical specialties were able

to free up beds, but others required more beds to meet the consistency of arrivals.

12. **WPMC occupancy averages three to six percent below national figures, and may be as much as 16 percent below national averages.** The average occupancy rate in the U.S., not including nursery beds, is between 73.4 percent and 76 percent occupancy. Wellbrock estimated occupancy levels in 1988 between 60.6 and 93.3. The 18-month average beginning in January 1988 was 70.2. Siml of this research found the Medical Center's occupancy ranged from an average low of 16 percent in the Critical Care Ward, to a high of 85 percent in the Orthopedic clinical specialty with the average occupancy for Siml of 59 percent (excluding the CCU and the nursery).

13. **Hospital clinical services varied widely in their simulated performance.** According to the simulation, the Medicine clinical specialty appears to be the only clinical specialty that is balancing beds to meet demand and maintaining one of the highest occupancies in the hospital. According to the simulation, the Medicine clinical specialty was operating with near optimum number of beds for that clinical specialty in 1988. The clinical specialty also maintained the highest occupancy in the hospital, 73 percent, without having patients waiting. While Orthopedics had an occupancy of 85 percent, patients were waiting for beds.

The Pediatric clinical specialty had the lowest occupancy in the hospital simulation except for the Critical Care Ward. Even though Pediatrics needed seven beds to keep patients from waiting, they only had an occupancy of 26 percent. This clearly points to either very erratic patient arrivals or very poor scheduling. There were numerous complaints on the survey of excess beds in Pediatrics.

Surgery and Mental Health also had excess capacity in the simulation. Surgery had six unused beds in Siml. Mental Health had 13 unused beds in Siml. Mental Health should be given some allowance due the nature of Aero Evac arrivals, but 13 is quite a large buffer for unexpected arrivals.

In the simulation, OB, GYN, and Orthopedics needed more beds to reduce patient waiting time according the simulation. In reality OB and GYN may have shared beds and OB patients may have used Labor and Delivery rooms.

14. **The major finding of the simulation: when maximum patient waiting time was set to 3.2 hours, there were enough beds in the hospital to meet demand.** After reallocation and assuming 1988 demand levels, patients should not need to wait if beds are allocated properly. The simulation research led to the conclusion WPMC had an extra capacity of at least four beds in 1988. Both simulations attempted to decrease patient waiting time. Using 222 beds as a base line, and total 1988 arrivals of 6995, there were enough beds to meet demand if patients were allowed to wait until 1512 once in a while. Though at times in 1988, wards were closed, allowances were made in the simulation for those wards.

Recommendations

1. **Continue maximizing the Same Day Surgery Unit.** That will ease strain upon hospital resources. Using the Same Surgery Unit will also continue good customer service by letting patients return home as soon as possible.

2. **Give critical care patients first priority for ward beds.** A survey respondent noted that if ICU patients cannot be stepped down into a normal ward, then ICU beds fill with non critical patients.

3. **Determine what data is needed to evaluate hospital operations and maintain it.** Wellbrock was not able to estimate occupancy levels because data was not kept. If occupancy levels are important indicators of a hospitals operating efficiency, then the number of supported beds must be kept on a daily basis.

4. **Return control of bed management to A&D.** A&D is the one agency dealing with bed management that is in a position to view the whole system. Let A&D administrators and clerks handle bed procedures. They have been trained for that role.

Physicians should neither schedule nor find beds, not because they are incapable, but because their time is better spent elsewhere. Their training is specialized in medicine, not administration. Returning control of beds to A&D will free physicians to visit patients, and take actions to help the patient get released on time. Physicians, of course, should still determine approximately when a patient should enter the hospital, just not the exact day (unless Emergency), and not the exact bed. Returning control of bed management to A&D will allow physicians to handle complex generalities, and A&D to handle the complex specifics.

5. **Create a total policy that coordinates the activities of all personnel involved with bed management.** The bed management "chain" can break at several key points. Several policy changes may be in order.

Free up physicians' schedules in the mornings to allow them time to make their rounds. Mandate that physicians decide during rounds whether to keep the patient another day or send the patient home. This will help clear up uncertainties for the patient, ward nurses, and A&D. Physicians should inform the patient and the ward staff by 0900. Physicians remind the patient that the patient should depart the room no later than 1100. This orderliness will strengthen the first link of the chain.

Having been told a patient will be released, the ward staff should prepare paperwork and pharmacy materials and notify housekeeping, and A&D. This should give A&D five hours notice. Re-notify housekeeping when the patient has left to allow them time to prepare the room. If ward nurses find it inconvenient to notify housekeeping, one solution could be to make housekeeping a stop or phone call on the patient's outprocessing list.

If rooms are needed, mandate that patients depart their room no later than 1100. Charge them for overstays if necessary.

A policy can only be enforced if hospital personnel agree and cooperate to move the patient from his room into a waiting area. While there may be exceptions, only a firm standard that applies to all will ensure the process runs smoothly.

Having been notified of departing patients at around 0900, housekeeping should have several hours to plan. Though they can not prepare all rooms at the same time, they should know which rooms to check. Housekeeping should have until 1330 to prepare rooms for use. Knowing that historically fewer than 30 patients a day arrive, this should not strain housekeeping personnel. Housekeeping should notify A&D as early as soon as the room is ready for a new patient.

Admissions and Dispositions should began sending incoming patients to rooms at as they return from lab work or lunch. Continue the practice of having patients complete lab work the morning of their admission.

This quick suggestion, though simple, improves on current practice. Policy forces information transfer, allows early planning, and gives key personnel a deadline by which to perform critical tasks. The process will break down at the first link to fail. At that time, the process can be reevaluated at the failure point and modified.

6. **If the phone is not convenient for communication, consider using electronic mail.** WPMC has computers capable of handling electronic mail. Most offices have at least one terminal. This recommendation would require programing,

terminal. This recommendation would require programing, software, and computer training to implement. One "letter" at the ward terminal addressed to all concerned parties could be sent with patient changes.

A variation on this theme would be to tie all parties into a real time information system. As ward nurses use the computer terminal to update a patient's records, A&D could see, without any coordination necessary, who is checking out, and when. If the pharmacy and housekeeping were tied into the network, then they would know the timing necessary on their part to ensure a smooth patient turnover.

7. Reexamine all clinical specialties to verify occupancy levels and bed allocation policies. Determine what Medicine clinical specialty is doing right (they may have a proper allocation of beds). Determine the cause of Pediatrics low occupancy. Confirm Surgery and Mental Health's excess capacity (they appear to have too many beds). Confirm OB, GYN, and Orthopedics need for more beds.

Determine why bed allocations are as they are. Is it due to equipment, tradition, or convenience? Is there a need to separate beds as much as they are?

Would a common pool of beds (excluding CCU, ICU, and OB) be more efficient? Pooling reduces differences which allows more specialties access to more beds. Beds could be more easily be managed and occupancy should be increased.

8. The most significant action necessary to improve bed management, is to develop a centralized scheduling system. To reduce idle beds and keep occupancy high requires planning. Scheduling is necessary to maximize resources and meet demand. Implementing a scheduling system requires modifications on several fronts. Since some of these recommendations are already operating effectively in hotel settings, a hotel analogy is used to communicate the potential for the recommendation.

First, since A&D is the natural focal point for bed actions, they should have centralized control of beds. While not undermining the importance of A&D, their position is similar to that of the front desk of a hotel. A&D is the control room. They are visible both to patients and to hospital staff. This visibility makes A&D a natural choice as prime department responsible for bed management. If all bed actions are coordinated through them, A&D could maintain a system's perspective--able to see the happenings of all wards. A&D will be able to make bed allocation decisions better than an individual ward would.

The responsibility A&D would be given for bed management should be coupled with authority for bed allocations. Require all departments to coordinate through A&D for beds. Before a clinical specialty schedules a patient they should contact A&D for a "reservation". In addition, even before Aero Evac patients are sent to WPMC, they should have A&D's permission. If A&D is to be held accountable for bed management, also give them the authority to turn patients away if beds will not be available.

A second suggestion is to "pool" all beds, excluding select groups, into a common group from which any specialty can get a bed. If clinical specialties commonly borrow beds, there may not be a significant reason to specialize those beds. Decreasing specialization will simplify scheduling. This would also cut down on inter-clinical specialty struggles over bed allocations. There may be valid reasons to keep certain beds separate from the pool, such as specialized equipment that is not portable, or isolation. But as much as practical the Medical Center should consider decreasing specialization among allocated beds.

Third, set up a bed reservation system. Before a patient can be admitted to the hospital, he must have a reservation. If there is not a projected bed available for the desired day of admissions, the patient must reschedule or perhaps be sent to a civilian hospital. The permission to use a bed should come only from the A&D office.

For Emergencies the bed reservation would be dependent on available beds at the time of entry. Beds could be reserved for Emergency arrivals and deducted from the total beds available for reservations. Consider Emergencies separate from Aero Evac and scheduled arrivals. Set aside a number of beds a day for Emergency arrivals, realizing at times arrivals may get as high as 11. Emergency patients will use an average of 17.32 beds a day (2.47 x 7.8 average length of stay) on an ongoing basis and the number of beds used could be higher.

Fourth, in much the same way hotels ask customers to estimate their stay, ask physicians to give a "reasonable" length of patient stay when asking for a bed reservation so planning can be done. Estimated information is better than no information or averages. A possibility is to use Disease Related Groupings (DRG's) to estimate the patient's length of stay.

Fifth, improve coordination with Aero Evac Headquarters. A phone or modem/computer link would allow Aero Evac to transmit information about arriving patients. As soon as Aero Evac Headquarters knows who is going to WPMC and when, they need to inform A&D. Then on the day of arrival, Aero Evac Headquarters should confirm who is arriving and the estimated time of arrival.

In summation, to improve efficiency, admissions should be scheduled systematically and medical staff should be willing to give up some control over the timing of their admissions (MacStravic, 1981).

9. **In the long term, consider converting to a seven day hospital to use resources more effectively.** One way to deal with census fluctuations is to operate as a six or seven day hospital. This would eliminate program and staffing drop off on weekends and holidays. OR scheduling would be more constant. It would make little difference to the patients, and staff could still be scheduled for two days off in a row. Although other compilations would arise, resource use would be more efficient.

bed scheduling would be easier, and more patients could be given care.

1Ø. Develop a Decision Support System. See page 163, "Suggestions for future research".

Suggestions For Future Research.

DSS. There is a need to know the impact of beds, patient stays, and arrivals on each individual ward/clinical specialty. Each clinical specialty has special circumstances that require specific information to determine the success of system modifications. A specific Decision Support System (DSS) would help at the clinical specialty level. A DSS aids managers in making decisions. The decision to be made would include several factors: number of beds required, number of patients to schedule. The author will keep a prototype DSS for up to five years (See vita for address).

A prototype created by the author of this study makes use of a microcomputer spreadsheet called Quattro and the simulation program Simple_1. It uses the Pediatrics database to determine arrivals by day of week for Emergency, Aero Evac, and Scheduled patients. Given the database, the spreadsheet computes the arrival rates as well as the percentage of arrivals by arrival source and prepares them for use by the simulation. The simulation reads the numbers and uses input variables, to determine the effect of a set number of beds on the clinical specialty/ward. After the simulation, the DSS breaks the simulation output into user friendly output.

Following the prototype format, a future developer could use the hospital database to get a flat ASCII file that could be used on a microcomputer or a mainframe. In May of 1989, the AQCESS system was updated to allow flat files. The hospital mainframe spreadsheet can also be used to analyze the output. The hospital mainframe computer has a spreadsheet that will go beyond the 640 kilobyte MS-DOS RAM restriction of a microcomputer. Transfer the edited information to a main frame at AFIT for a statistical analysis, then use either the simulation program there or a mainframe program to complete the DSS.

Hotel Bed Reservation System. The similarities between a hospital and a hotel are striking. Both have unexpected demand as well as scheduled demand. Both schedule beds. Neither a hospital nor a hotel knows for certain when a person will check out. There may be ideas and software that could be borrowed from the motel industry.

Summary

Many recommendations could be made that would aid WPMC to improve in small ways. Chapter V has discussed some major projects to help the Medical Center improved their admissions and dispositions process. In general, by clarifying lines of communication, authority and responsibility, great improvements would be made. Specifically, by developing a scheduling system the hospital would better balance resources against demand. Future research could aid the effort by creating a decision support system and also by considering application of hotel principles to the admissions and dispositions process.

APPENDIX A: DATABASE REQUEST LETTER

From: Captain Dan Cheek (AFIT/LSG) 5-4437
To: Wright-Patterson Medical Communications Center

3 March 89

1. The hospital has experienced bed shortage problems in the past. To understand this problem better, part of my research effort is to statistically analyze portions of the hospital database. My goal is to define trends regarding types of patients and lengths of stays and how this affects the hospital use of beds. Your accurate extraction of the hospital database is critical to this research and will ensure that I can give hospital personnel reliable information.

2. In accordance with the letter from Colonel Tuttle, please prepare a hard copy of the following:

The following information on patients who were admitted into the hospital between January 1, 1988 and March 1, 1989 (14 months of information on inpatients only excluding newborns).

File 8000
Current Register Number (17)
DOB (5)
Major Command (44)
Patient Category (6)
Patient City (21)
Patient Name (.01)
Primary Care Provider (29)
Sex (7)
Sponsor Rank (41)
SSN (4)
Zip Code (23)

File 8000.01
ADM Date/Time (2)
ADM Diag Code (4)
ADM Diag Text (16)
Admission from ER (110)
Bed (83)
Cancel Reason (80)
Casualty Date NOK Notified (72)
Casualty Roster Date (73)
Casualty Status (70)

Clincial Service (8)
Date ADM Entered (21)
Date Disp Entered (26)
Disp Date/Time (3)
Disp MTF (11)
Disp Type (10)
Initial ADM Date (TRF In) (64)
Initial ADM MTF (63)
Length SVC (17)
MEB Candidate (65)
MEB Date Confirmed (66)
MEB Date Identified (68)
MEB Date Resolved (69)
Previous ADM (22)
Primary Disp Diagnosis (105)
Proj Disp Date (24)
Proj Disp Type (23)
Room (82)
Source Admission (5)
Ward (9)
Ward Date/Time (15)

3. Also please allow me to print, photocopy, or borrow needed related tables that are necessary to interpret the file. Tables apparently needed are 1002, 1017, 1004, 1006, 2011, 2005, 2007, 2010, 2001, 8010.

4. In general I am looking for anything that affects the use of beds including source of admission, length of stay, ward, type of disease. I am also trying to profile a typical patient. That is the reason for Age, Sex, etc. I also need to ensure that I know who is Active Duty and what branch, or if a dependent. I'm not sure that I found that information. Also, there is a code for Emergencies, but is there any way to tell if a patient came in on the Aero Evac? Finally, I do not want information on newborns.

5. I know that this will take some time. Call me when you have it ready or if you have further questions. Home Number is 879-3242 or work 255-4437.

Thank you,

Dan Cheek

APPENDIX B: DATABASE CLINCAL ANALYSIS

	AAA	AAA CCU	AAB	AAB CCU	AAC	AAC CCU	AAD	AAE
PATIENTS	791	15	790	116	10	21	1	1
AVG	8.16	18.93	6.15	3.03	7.70	6.38	1.00	5.00
MIN	0	1	1	1	2	1	1	5
MAX	133	63	89	31	32	10	1	1
PER	11.32%	0.21%	11.31%	1.66%	0.14%	0.30%	0.01%	0.01%

	AAF	AAG	AAH	AAH CCU	AAI	AAJ	AAK	AAL
PATIENTS	16	9	8	2	24	7	113	52
AVG	7.63	7.56	15.88	1.00	12.38	6.43	9.08	6.85
MIN	2	1	4	1	1	1	1	1
MAX	24	22	37	1	64	125	106	34
PER	0.23%	0.13%	0.11%	0.03%	0.34%	0.10%	1.62%	0.74%

	ABA	ABB	ABC	ABD	ABE	ABF	ABG	ABI
PATIENTS	934	94	11	142	93	221	259	58
AVG	7.18	8.57	18.55	10.71	4.22	2.98	3.36	3.76
MIN	1	1	5	1	0	1	1	1
MAX	179	95	42	119	30	65	86	35
PER	13.37%	1.35%	0.16%	2.03%	1.33%	3.16%	3.71%	0.83%

	ABJ	ABK	ACA	ACB	ADA	AEA	AEB
PATIENTS	1	351	493	1170	215	592	63
AVG	23.00	4.05	4.27	4.58	3.31	8.64	4.95
MIN	23	1	1	1	1	1	1
MAX	23	88	65	61	26	106	51
PER	0.01%	5.03%	7.06%	16.75%	3.08%	8.48%	0.90%

	AFA	AFB
PATIENTS	198	117
AVG	36.61	25.55
MIN	1	2
MAX	242	49
PER	2.83%	1.68%

Note: These numbers include outliers, that were removed prior to computing the means for use in the simulation. See the Appendix C for an explanation of service codes.

APPENDIX C: CLINICAL SERVICE SPECIALTY CODES

FOR THE CCU WARD

AAA INTERNAL MEDICINE
AAB CARDIOLOGY
AAC CORONARY CARE UNIT
AAH INTENSIVE CARE (MEDICINE)

OTHERWISE

MEDICINE SPECIALTIES

AAA INTERNAL MEDICINE
AAB CARDIOLOGY
AAC CORONARY CARE UNIT
AAD DERMATOLOGY
AAE ENDOCRINOLOGY
AAF GASTROENTEROLOGY
AAG HEMOTOLOGY
AAH INTESNSIVE CARE (MEDICINE)
AAI MEPHROLOGY
AAJ NEUROLOGY
AAK ONCOLOGY
AAL PULMONARY UPPER RESPIR (NON-TB)

SURGERY SPECIALTIES

ABA GENERAL SURGERY
ABB THORACTIC/CARDIOVASC SURG
ABC INTENSIVE CARE (SURGICAL)
ABD NEUROSURGERY
ABE OPHTHALMOLOGY
ABF ORAL SURGERY
ABG OTORHINOLARYNGOLOGY
ABH PEDIATRIC SURGERY
ABI PLASTIC SURGERY
ABJ PROCTOLOGY
ABK UROLOGY

ACA GYNECOLOGY
ACB OBSTERTRICS

ADA PEDIATRICS

AEA ORTHOPEDICS
AEB PODIATRY

AFA PSYCHIATRIC CARE
AFB SUBSTANCE ABUSE REHAB

APPENDIX D: PATIENT ARRIVAL STATISTICS

TOTAL ARRIVALS BY WEEK OF YEAR

	1	2	3	4	5	6	7	8	9
INPATIENTS	180	171	130	162	159	187	153	153	129
DAYS	7	7	7	7	7	7	7	7	7
STD	10.25	8.67	7.63	10.32	9.47	8.38	9.99	5.96	9.84
VAR	105.06	75.10	58.24	106.41	89.63	70.20	99.84	35.55	96.82
MEAN	3.46	3.29	2.50	3.12	3.06	3.60	2.94	2.94	2.48
MEAN/WK	25.71	24.43	18.57	23.14	22.71	26.71	21.86	21.86	18.43

10	11	12	13	14	15	16	17	18	19
146	143	150	163	163	130	147	120	133	132
7	7	7	7	7	7	7	7	7	7
6.31	7.74	7.11	11.32	6.09	6.67	7.01	5.44	6.28	9.69
39.84	59.96	50.53	128.20	37.06	44.53	49.14	29.55	39.43	93.84
2.81	2.75	2.88	3.13	3.13	2.50	2.83	2.31	2.56	2.54
20.86	20.43	21.43	23.29	23.29	18.57	21.00	17.14	19.00	18.86

20	21	22	23	24	25	26	27	28	28
130	110	99	123	108	130	119	108	135	135
7	7	7	7	7	7	7	7	7	7
8.24	4.46	7.61	4.20	5.90	8.21	6.89	6.54	5.28	5.28
67.96	19.92	57.84	17.67	34.82	67.39	47.43	42.82	27.92	27.92
2.50	2.12	1.90	2.37	2.08	2.50	2.29	2.08	2.60	2.60
18.57	15.71	14.14	17.57	15.43	18.57	17.00	15.43	19.29	19.29

30	29	32	31	34	33	36	35	38	37
141	134	143	140	135	158	143	151	147	137
7	7	7	7	7	7	7	7	7	7
6.36	6.27	4.84	5.63	7.28	9.71	10.70	10.07	6.14	7.19
40.41	39.27	23.39	31.71	53.06	94.24	114.53	101.39	37.71	51.67
2.71	2.58	2.75	2.69	2.60	3.04	2.75	2.90	2.83	2.63
20.14	19.14	20.43	20.00	19.29	22.57	20.43	21.57	21.00	19.57

40	39	42	41	44	45	46	47	48	49
142	141	148	130	139	126	151	111	151	145
7	7	7	7	7	7	7	7	7	7
6.58	8.95	5.67	8.36	6.22	8.19	9.33	7.88	8.70	6.23
43.35	80.12	32.12	69.96	38.69	67.14	87.10	62.12	75.67	38.78
2.73	2.71	2.85	2.50	2.67	2.42	2.90	2.13	2.90	2.79
20.29	20.14	21.14	18.57	19.86	18.00	21.57	15.86	21.57	20.71

50	51	52
146	100	116
7	7	9
7.61	3.49	3.38
57.84	12.20	11.43
2.81	1.92	2.23
20.86	14.29	16.57

TOTAL ARRIVALS BY MONTH OF YEAR

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
TOTAL	684	654	690	577	552	517	555	655	613
COUNT	31	29	31	30	31	30	31	31	30
STD	9.77	9.66	7.82	7.14	7.71	6.36	6.79	7.91	8.13
VAR	95.48	93.28	61.22	50.91	59.45	40.45	46.09	62.50	66.05
DAILY MEAN	22.06	21.10	22.26	18.61	17.81	16.68	17.90	21.13	19.77

	OCT	NOV	DEC
TOTAL	606	584	533
COUNT	31	30	31
STD	7.61	8.56	6.47
VAR	57.93	73.32	41.83
DAILY MEAN	19.55	18.84	17.19

APPENDIX E: TOTAL ARRIVALS RAW DATA

Actual count data

DATE	TOTAL PAT	EMER	EST. AERO EVAC	SCHED	DAY	WEEK#
01-Jan-88	11	6	0	5	FR	52
02-Jan-88	8	3	0	5	SA	52
03-Jan-88	23	0	0	23	SU	1
04-Jan-88	40	2	3	35	MO	1
05-Jan-88	26	0	0	26	TU	1
06-Jan-88	37	3	5	29	WE	1
07-Jan-88	30	2	0	28	TH	1
08-Jan-88	13	5	3	5	FR	1
09-Jan-88	11	4	1	6	SA	1
10-Jan-88	30	2	2	26	SU	2
11-Jan-88	35	1	1	33	MO	2
12-Jan-88	25	1	0	24	TU	2
13-Jan-88	32	0	3	29	WE	2
14-Jan-88	24	4	0	20	TH	2
15-Jan-88	17	0	4	13	FR	2
16-Jan-88	8	2	0	6	SA	2
17-Jan-88	7	2	3	2	SU	3
18-Jan-88	23	3	3	17	MO	3
19-Jan-88	28	2	0	26	TU	3
20-Jan-88	21	1	2	18	WE	3
21-Jan-88	23	1	0	22	TH	3
22-Jan-88	21	2	13	6	FR	3
23-Jan-88	7	4	0	29	SA	3
24-Jan-88	32	3	0	35	SU	4
25-Jan-88	38	3	5	13	MO	4
26-Jan-88	22	4	0	28	TU	4
27-Jan-88	29	1	3	16	WE	4
28-Jan-88	19	0	0	19	TH	4
29-Jan-88	18	3	5	10	FR	4
30-Jan-88	4	0	0	4	SA	4
31-Jan-88	22	3	6	13	SU	5
01-Feb-88	40	3	1	36	MO	5
02-Feb-88	21	1	0	20	TU	5
03-Feb-88	22	1	3	18	WE	5
04-Feb-88	31	1	1	29	TH	5
05-Feb-88	13	2	4	7	FR	5
06-Feb-88	10	5	0	5	SA	5
07-Feb-88	31	2	0	29	SU	6
08-Feb-88	37	3	1	33	MO	6
09-Feb-88	22	1	0	21	TU	6
10-Feb-88	34	1	4	29	WE	6
11-Feb-88	32	2	0	30	TH	6

12-Feb-88	18	2	7	9	FR	6
13-Feb-88	13	3	6	4	SA	6
14-Feb-88	10	3	0	7	SU	7
15-Feb-88	24	4	3	17	MO	7
16-Feb-88	33	1	0	32	TU	7
17-Feb-88	36	4	1	31	WE	7
18-Feb-88	26	2	0	24	TH	7
19-Feb-88	15	1	5	9	FR	7
20-Feb-88	9	0	3	16	SA	7
21-Feb-88	21	2	0	28	SU	8
22-Feb-88	28	0	3	18	MO	8
23-Feb-88	22	1	0	21	TU	8
24-Feb-88	31	1	4	26	WE	8
25-Feb-88	21	1	0	20	TH	8
26-Feb-88	19	1	5	13	FR	8
27-Feb-88	11	1	0	10	SA	8
28-Feb-88	24	0	5	19	SU	9
29-Feb-88	30	3	5	22	MO	9
01-Mar-88	28	2	0	26	TU	9
02-Mar-88	27	0	2	25	WE	9
03-Mar-88	26	1	4	21	TH	9
04-Mar-88	13	1	0	12	FR	9
05-Mar-88	11	2	6	3	SA	9
06-Mar-88	22	3	0	19	SU	10
07-Mar-88	21	1	3	17	MO	10
08-Mar-88	28	1	7	20	TU	10
09-Mar-88	22	1	2	19	WE	10
10-Mar-88	29	2	0	27	TH	10
11-Mar-88	13	1	5	7	FR	10
12-Mar-88	11	2	0	9	SA	10
13-Mar-88	25	2	0	23	SU	11
14-Mar-88	32	2	0	30	MO	11
15-Mar-88	23	1	0	22	TU	11
16-Mar-88	23	2	1	20	WE	11
17-Mar-88	21	3	3	15	TH	11
18-Mar-88	12	0	0	12	FR	11
19-Mar-88	7	4	1	2	SA	11
20-Mar-88	22	1	0	21	SU	12
21-Mar-88	27	0	5	22	MO	12
22-Mar-88	33	0	0	33	TU	12
23-Mar-88	21	1	3	17	WE	12
24-Mar-88	23	0	3	20	TH	12
25-Mar-88	10	2	0	8	FR	12
26-Mar-88	14	4	2	8	SA	12
27-Mar-88	23	1	0	22	SU	13
28-Mar-88	43	3	8	32	MO	13
29-Mar-88	29	1	2	26	TU	13
30-Mar-88	29	1	9	19	WE	13
31-Mar-88	22	0	0	22	TH	13
01-Apr-88	10	1	4	5	FR	13
02-Apr-88	7	3	0	4	SA	13
03-Apr-88	25	0	0	25	SU	14

04-Apr-88	34	0	3	31	MO	14
05-Apr-88	23	4	0	19	TU	14
06-Apr-88	28	0	4	24	WE	14
07-Apr-88	21	1	0	20	TH	14
08-Apr-88	18	0	0	18	FR	14
09-Apr-88	14	1	0	13	SA	14
10-Apr-88	19	3	0	16	SU	15
11-Apr-88	24	0	4	20	MO	15
12-Apr-88	22	2	0	20	TU	15
13-Apr-88	28	0	2	26	WE	15
14-Apr-88	17	1	0	16	TH	15
15-Apr-88	14	2	3	9	FR	15
16-Apr-88	6	1	0	5	SA	15
17-Apr-88	29	5	0	24	SU	16
18-Apr-88	26	2	0	24	MO	16
19-Apr-88	24	2	0	22	TU	16
20-Apr-88	27	1	2	24	WE	16
21-Apr-88	16	0	0	16	TH	16
22-Apr-88	17	1	3	13	FR	16
23-Apr-88	8	0	2	6	SA	16
24-Apr-88	19	2	0	17	SU	17
25-Apr-88	25	0	5	20	MO	17
26-Apr-88	19	2	0	17	TU	17
27-Apr-88	18	0	0	18	WE	17
28-Apr-88	19	1	0	18	TH	17
29-Apr-88	14	2	3	9	FR	17
30-Apr-88	6	0	3	3	SA	17
01-May-88	18	2	0	16	SU	18
02-May-88	25	2	0	23	MO	18
03-May-88	26	3	0	23	TU	18
04-May-88	12	2	0	10	WE	18
05-May-88	23	0	0	23	TH	18
06-May-88	21	3	4	14	FR	18
07-May-88	8	0	1	7	SA	18
08-May-88	14	1	0	13	SU	19
09-May-88	24	0	0	24	MO	19
10-May-88	19	1	0	18	TU	19
11-May-88	40	0	3	37	WE	19
12-May-88	13	1	0	12	TH	19
13-May-88	12	0	0	12	FR	19
14-May-88	10	2	0	8	SA	19
15-May-88	8	0	0	8	SU	20
16-May-88	34	3	3	28	MO	20
17-May-88	19	1	0	18	TU	20
18-May-88	14	1	4	9	WE	20
19-May-88	23	2	0	21	TH	20
20-May-88	22	3	5	14	FR	20
21-May-88	10	2	0	8	SA	20
22-May-88	22	2	0	20	SU	21
23-May-88	18	0	1	17	MO	21
24-May-88	17	3	0	14	TU	21
25-May-88	11	0	0	11	WE	21

26-May-88	2Ø	1	1	18	TH	21
27-May-88	13	2	2	9	FR	21
28-May-88	9	1	2	6	SA	21
29-May-88	4	1	Ø	3	SU	22
3Ø-May-88	18	4	Ø	14	MO	22
31-May-88	25	3	Ø	22	TU	22
Ø1-Jun-88	22	2	1	19	WE	22
Ø2-Jun-88	8	Ø	Ø	8	TH	22
Ø3-Jun-88	16	Ø	3	13	FR	22
Ø4-Jun-88	6	1	1	4	SA	22
Ø5-Jun-88	13	2	Ø	11	SU	23
Ø6-Jun-88	26	Ø	2	24	MO	23
Ø7-Jun-88	15	1	Ø	14	TU	23
Ø8-Jun-88	21	2	2	17	WE	23
Ø9-Jun-88	14	Ø	Ø	14	TH	23
1Ø-Jun-88	17	Ø	2	15	FR	23
11-Jun-88	17	Ø	5	12	SA	23
12-Jun-88	12	2	Ø	1Ø	SU	24
13-Jun-88	21	2	1	18	MO	24
14-Jun-88	2Ø	1	Ø	19	TU	24
15-Jun-88	24	1	4	19	WE	24
16-Jun-88	12	1	Ø	11	TH	24
17-Jun-88	13	2	5	6	FR	24
18-Jun-88	6	Ø	Ø	8	SA	24
19-Jun-88	9	1	Ø	31	SU	25
2Ø-Jun-88	33	2	8	15	MO	25
21-Jun-88	24	1	Ø	23	TU	25
22-Jun-88	21	Ø	Ø	21	WE	25
23-Jun-88	17	3	Ø	14	TH	25
24-Jun-88	19	2	4	13	FR	25
25-Jun-88	7	Ø	Ø	7	SA	25
26-Jun-88	18	2	2	14	SU	26
27-Jun-88	25	2	2	21	MO	26
28-Jun-88	23	2	Ø	21	TU	26
29-Jun-88	18	2	1	15	WE	26
3Ø-Jun-88	2Ø	Ø	Ø	2Ø	TH	26
Ø1-Jul-88	12	3	3	6	FR	26
Ø2-Jul-88	3	Ø	3	Ø	SA	26
Ø3-Jul-88	9	3	Ø	6	SU	27
Ø4-Jul-88	13	2	2	9	MO	27
Ø5-Jul-88	29	5	Ø	24	TU	27
Ø6-Jul-88	21	2	3	16	WE	27
Ø7-Jul-88	13	3	Ø	1Ø	TH	27
Ø8-Jul-88	12	4	2	6	FR	27
Ø9-Jul-88	11	2	Ø	9	SA	27
1Ø-Jul-88	18	3	Ø	15	SU	28
11-Jul-88	27	5	1	21	MO	28
12-Jul-88	23	3	Ø	2Ø	TU	28
13-Jul-88	23	2	1	2Ø	WE	28
14-Jul-88	2Ø	4	Ø	16	TH	28
15-Jul-88	12	2	3	7	FR	28
16-Jul-88	12	6	Ø	6	SA	28

17-Jul-88	17	5	0	12	SU	29
18-Jul-88	25	3	4	18	MO	29
19-Jul-88	16	2	0	14	TU	29
20-Jul-88	23	3	0	20	WE	29
21-Jul-88	24	8	0	16	TH	29
22-Jul-88	23	9	6	8	FR	29
23-Jul-88	6	3	0	3	SA	29
24-Jul-88	22	6	1	15	SU	30
25-Jul-88	28	2	3	23	MO	30
26-Jul-88	26	1	0	25	TU	30
27-Jul-88	23	5	2	16	WE	30
28-Jul-88	20	10	0	10	TH	30
29-Jul-88	13	4	1	8	FR	30
30-Jul-88	9	4	0	5	SA	30
31-Jul-88	22	8	5	9	SU	31
01-Aug-88	21	3	3	15	MO	31
02-Aug-88	24	1	0	23	TU	31
03-Aug-88	28	6	5	17	WE	31
04-Aug-88	21	6	0	15	TH	31
05-Aug-88	14	4	6	4	FR	31
06-Aug-88	10	3	1	6	SA	31
07-Aug-88	15	4	0	11	SU	32
08-Aug-88	23	3	0	20	MO	32
09-Aug-88	18	2	0	16	TU	32
10-Aug-88	25	6	2	17	WE	32
11-Aug-88	22	2	0	20	TH	32
12-Aug-88	27	2	9	16	FR	32
13-Aug-88	13	3	7	3	SA	32
14-Aug-88	16	3	0	13	SU	33
15-Aug-88	38	9	2	27	MO	33
16-Aug-88	27	3	0	24	TU	33
17-Aug-88	31	6	0	25	WE	33
18-Aug-88	24	6	0	18	TH	33
19-Aug-88	14	6	5	3	FR	33
20-Aug-88	8	3	0	5	SA	33
21-Aug-88	17	5	0	12	SU	34
22-Aug-88	30	4	1	25	MO	34
23-Aug-88	24	4	0	20	TU	34
24-Aug-88	25	5	3	17	WE	34
25-Aug-88	20	3	0	17	TH	34
26-Aug-88	11	3	5	3	FR	34
27-Aug-88	8	3	0	5	SA	34
28-Aug-88	10	2	0	8	SU	35
29-Aug-88	38	4	8	26	MO	35
30-Aug-88	25	3	0	22	TU	35
31-Aug-88	28	6	4	18	WE	35
01-Sep-88	26	9	0	17	TH	35
02-Sep-88	17	6	3	8	FR	35
03-Sep-88	7	5	0	2	SA	35
04-Sep-88	9	4	0	5	SU	36
05-Sep-88	23	1	6	16	MO	36
06-Sep-88	40	2	0	38	TU	36

07-Sep-88	22	1	4	17	WE	36
08-Sep-88	28	3	0	25	TH	36
09-Sep-88	14	1	2	11	FR	36
10-Sep-88	7	1	4	2	SA	36
11-Sep-88	20	3	0	17	SU	37
12-Sep-88	30	2	0	28	MO	37
13-Sep-88	21	3	0	18	TU	37
14-Sep-88	25	1	5	19	WE	37
15-Sep-88	22	5	0	17	TH	37
16-Sep-88	12	2	2	8	FR	37
17-Sep-88	7	2	3	2	SA	37
18-Sep-88	22	3	0	19	SU	38
19-Sep-88	29	6	3	20	MO	38
20-Sep-88	23	3	0	20	TU	38
21-Sep-88	22	4	0	18	WE	38
22-Sep-88	26	5	0	21	TH	38
23-Sep-88	16	2	6	8	FR	38
24-Sep-88	9	3	0	6	SA	38
25-Sep-88	17	2	0	15	SU	39
26-Sep-88	37	3	5	29	MO	39
27-Sep-88	24	4	0	20	TU	39
28-Sep-88	23	4	0	19	WE	39
29-Sep-88	18	1	0	17	TH	39
30-Sep-88	17	1	5	11	FR	39
01-Oct-88	5	0	0	5	SA	39
02-Oct-88	23	2	0	21	SU	40
03-Oct-88	30	2	1	27	MO	40
04-Oct-88	23	1	0	22	TU	40
05-Oct-88	24	3	5	16	WE	40
06-Oct-88	20	3	0	17	TH	40
07-Oct-88	13	2	3	8	FR	40
08-Oct-88	9	8	0	1	SA	40
09-Oct-88	[illegible]	1	0	5	SU	41
10-Oct-88	17	3	6	8	MO	41
11-Oct-88	26	3	0	23	TU	41
12-Oct-88	34	9	5	20	WE	41
13-Oct-88	17	1	0	16	TH	41
14-Oct-88	17	0	2	15	FR	41
15-Oct-88	13	2	7	4	SA	41
16-Oct-88	18	3	3	12	SU	42
17-Oct-88	30	0	0	30	MO	42
18-Oct-88	22	6	0	16	TU	42
19-Oct-88	24	3	2	19	WE	42
20-Oct-88	23	2	0	21	TH	42
21-Oct-88	21	3	5	13	FR	42
22-Oct-88	10	3	2	5	SA	42
23-Oct-88	13	5	0	8	SU	43
24-Oct-88	31	7	6	18	MO	43
25-Oct-88	27	6	0	21	TU	43
26-Oct-88	21	2	2	17	WE	43
27-Oct-88	21	9	0	12	TH	43
28-Oct-88	12	2	2	8	FR	43

29-Oct-88	7	1	Ø	6	SA	43
3Ø-Oct-88	2Ø	6	Ø	14	SU	44
31-Oct-88	29	1	2	26	MO	44
Ø1-Nov-88	2Ø	4	Ø	16	TU	44
Ø2-Nov-88	24	2	2	2Ø	WE	44
Ø3-Nov-88	21	7	Ø	14	TH	44
Ø4-Nov-88	18	6	6	6	FR	44
Ø5-Nov-88	7	2	Ø	5	SA	44
Ø6-Nov-88	25	2	7	16	SU	45
Ø7-Nov-88	18	3	Ø	15	MO	45
Ø8-Nov-88	3Ø	4	Ø	26	TU	45
Ø9-Nov-88	22	3	7	12	WE	45
1Ø-Nov-88	17	4	Ø	13	TH	45
11-Nov-88	4	2	Ø	2	FR	45
12-Nov-88	1Ø	7	Ø	3	SA	45
13-Nov-88	22	3	Ø	19	SU	46
14-Nov-88	33	3	7	23	MO	46
15-Nov-88	31	5	Ø	26	TU	46
16-Nov-88	22	1	5	16	WE	46
17-Nov-88	22	6	Ø	16	TH	46
18-Nov-88	19	3	2	14	FR	46
19-Nov-88	2	1	Ø	1	SA	46
2Ø-Nov-88	2Ø	3	Ø	17	SU	47
21-Nov-88	31	7	1	23	MO	47
22-Nov-88	16	3	Ø	13	TU	47
23-Nov-88	18	3	1	14	WE	47
24-Nov-88	6	5	Ø	1	TH	47
25-Nov-88	13	Ø	7	6	FR	47
26-Nov-88	7	2	Ø	5	SA	47
27-Nov-88	2Ø	5	Ø	15	SU	48
28-Nov-88	36	6	Ø	3Ø	MO	48
29-Nov-88	21	1	Ø	2Ø	TU	48
3Ø-Nov-88	29	2	3	24	WE	48
Ø1-Dec-88	17	3	Ø	14	TH	48
Ø2-Dec-88	22	4	8	1Ø	FR	48
Ø3-Dec-88	6	1	Ø	5	SA	48
Ø4-Dec-88	18	2	Ø	16	SU	49
Ø5-Dec-88	32	4	Ø	28	MO	49
Ø6-Dec-88	27	3	5	19	TU	49
Ø7-Dec-88	22	2	Ø	2Ø	WE	49
Ø8-Dec-88	17	6	Ø	11	TH	49
Ø9-Dec-88	16	4	1	11	FR	49
1Ø-Dec-88	13	4	4	5	SA	49
11-Dec-88	21	4	Ø	17	SU	5Ø
12-Dec-88	3Ø	2	4	24	MO	5Ø
13-Dec-88	24	4	Ø	2Ø	TU	5Ø
14-Dec-88	26	1	4	21	WE	5Ø
15-Dec-88	25	4	Ø	21	TH	5Ø
16-Dec-88	14	Ø	1	13	FR	5Ø
17-Dec-88	6	1	Ø	5	SA	5Ø
18-Dec-88	14	2	Ø	12	SU	51
19-Dec-88	18	2	4	12	MO	51

20-Dec-88	16	2	0	14	TU	51
21-Dec-88	16	2	1	13	WE	51
22-Dec-88	12	4	2	6	TH	51
23-Dec-88	17	3	2	12	FR	51
24-Dec-88	7	4	0	3	SA	51
25-Dec-88	9	7	0	2	SU	52
26-Dec-88	15	6	0	9	MO	52
27-Dec-88	13	3	0	10	TU	52
28-Dec-88	18	6	0	12	WE	52
29-Dec-88	13	4	0	9	TH	52
30-Dec-88	18	3	6	9	FR	52
31-Dec-88	11	4	0	7	SA	52

SUMMATION TOTAL DATA

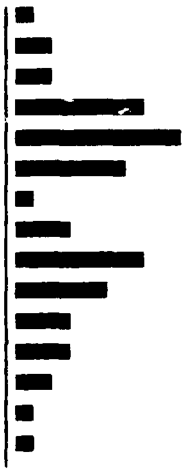
TOTAL	7250	923	588	5784
STD	8.06	1.97	2.25	7.97
VAR	64.96	3.84	5.06	63.30
MEAN	19.81	2.52	1.61	15.80

APPENDIX F: TOTAL ARRIVAL ANALYSIS

WEEK	FRI	SAT	SUN	MON	TUE	WED	THU
1	11.000	8.0000	23.000	40.000	26.000	37.000	30.000
2	13.000	11.000	30.000	35.000	25.000	32.000	24.000
3	17.000	8.0000	7.0000	23.000	28.000	21.000	23.000
4	21.000	7.0000	32.000	38.000	22.000	29.000	19.000
5	18.000	4.0000	22.000	40.000	21.000	22.000	31.000
6	13.000	10.000	31.000	37.000	22.000	34.000	32.000
7	18.000	13.000	10.000	24.000	33.000	36.000	26.000
8	15.000	9.0000	21.000	28.000	22.000	31.000	21.000
9	19.000	11.000	24.000	30.000	28.000	27.000	26.000
10	13.000	11.000	22.000	21.000	28.000	22.000	29.000
11	13.000	11.000	25.000	32.000	23.000	23.000	21.000
12	12.000	7.0000	22.000	27.000	33.000	21.000	23.000
13	10.000	14.000	23.000	43.000	29.000	29.000	22.000
14	10.000	7.0000	25.000	34.000	23.000	28.000	21.000
15	18.000	14.000	19.000	24.000	22.000	28.000	17.000
16	14.000	6.0000	23.000	26.000	24.000	27.000	16.000
17	17.000	8.0000	19.000	25.000	19.000	18.000	19.000
18	14.000	6.0000	18.000	25.000	26.000	12.000	23.000
19	21.000	8.0000	14.000	24.000	19.000	40.000	13.000
20	12.000	10.000	8.0000	34.000	19.000	14.000	23.000
21	22.000	10.000	22.000	18.000	17.000	11.000	20.000
22	13.000	9.0000	4.0000	18.000	25.000	22.000	8.0000
23	16.000	6.0000	13.000	26.000	15.000	21.000	14.000
24	17.000	17.000	12.000	21.000	20.000	24.000	12.000
25	13.000	6.0000	9.0000	33.000	24.000	21.000	17.000
26	19.000	7.0000	18.000	25.000	23.000	18.000	20.000
27	12.000	3.0000	9.0000	13.000	29.000	21.000	13.000
28	12.000	11.000	18.000	27.000	23.000	23.000	20.000
29	12.000	12.000	17.000	25.000	16.000	23.000	24.000
30	23.000	6.0000	22.000	28.000	26.000	23.000	20.000
31	13.000	9.0000	22.000	21.000	24.000	28.000	21.000
32	14.000	10.000	15.000	23.000	18.000	25.000	22.000
33	27.000	13.000	16.000	38.000	27.000	31.000	24.000
34	14.000	8.0000	17.000	30.000	24.000	25.000	20.000
35	11.000	8.0000	10.000	38.000	25.000	28.000	26.000
36	17.000	7.0000	9.0000	23.000	40.000	22.000	28.000
37	14.000	7.0000	20.000	30.000	21.000	25.000	22.000
38	12.000	7.0000	22.000	29.000	23.000	22.000	26.000
39	16.000	9.0000	17.000	37.000	24.000	23.000	18.000
40	17.000	5.0000	23.000	30.000	23.000	24.000	20.000
41	13.000	9.0000	6.0000	17.000	26.000	34.000	17.000
42	17.000	13.000	18.000	30.000	22.000	24.000	23.000
43	21.000	10.000	13.000	31.000	27.000	21.000	21.000
44	12.000	7.0000	20.000	29.000	20.000	24.000	21.000
45	18.000	7.0000	25.000	18.000	30.000	22.000	17.000
46	4.0000	10.000	22.000	33.000	31.000	22.000	22.000
47	19.000	2.0000	20.000	31.000	16.000	18.000	6.0000
48	13.000	7.0000	20.000	36.000	21.000	29.000	17.000
49	22.000	6.0000	18.000	32.000	27.000	22.000	17.000
50	16.000	13.000	21.000	30.000	24.000	26.000	25.000
51	14.000	6.0000	14.000	18.000	16.000	16.000	12.000
52	17.000	7.0000	9.0000	15.000	13.000	18.000	13.000
53	18.000	11.000	M	M	M	M	M

FREQUENCY DISTRIBUTION OF FRI

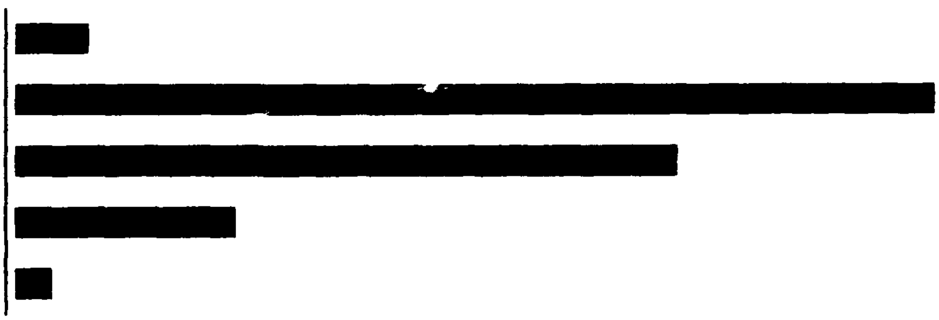
VALUE	N
4	1
10	2
11	2
12	7
13	9
14	6
15	1
16	3
17	7
18	5
19	3
21	3
22	2
23	1
27	1



NON-MISSING	53
MISSING	0
TOTAL	53

HISTOGRAM OF FRI

LOW	HIGH	N
5.00	10.00	2
10.00	15.00	25
15.00	20.00	18
20.00	25.00	6
25.00	30.00	1



CASES INCLUDED 52   MISSING CASES 0

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
FRI	15.42	4.012	53	14.00	4.000	27.00

FREQUENCY DISTRIBUTION OF SAT

VALUE	N
2	1
3	1
4	1
5	1
6	7
7	11
8	6
9	5
10	6
11	6
12	1
13	4
14	2
17	1

NON-MISSING	53
MISSING	0
TOTAL	53

HISTOGRAM OF SAT

LOW	HIGH	N
2.00	4.00	3
4.00	6.00	8
6.00	8.00	17
8.00	10.00	11
10.00	12.00	7
12.00	14.00	6
14.00	16.00	0
16.00	18.00	1

CASES INCLUDED 53 MISSING CASES 0

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
SAT	8.698	2.946	53	8.000	2.000	17.00

FREQUENCY DISTRIBUTION OF SUN

VALUE	N
4	1
6	1
7	1
8	1
9	4
10	2
12	1
13	2
14	2
15	1
16	1
17	3
18	5
19	2
20	4
21	2
22	8
23	3
24	1
25	3
29	1
30	1
31	1
32	1

TOTAL 53

HISTOGRAM OF SUN

LOW	HIGH	N
4.00	8.00	4
8.00	12.00	7
12.00	16.00	6
16.00	20.00	14
20.00	24.00	14
24.00	28.00	3
28.00	32.00	4

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
SUN	18.17	6.564	52	19.00	4.000	32.00

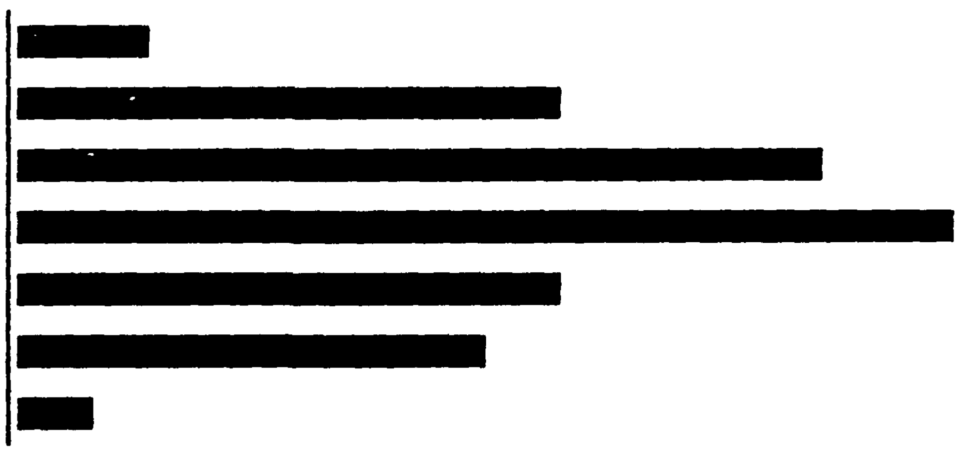
FREQUENCY DISTRIBUTION OF MON

VALUE	N
13	1
15	1
17	1
18	4
21	3
23	3
24	3
25	4
26	2
27	2
28	2
29	2
30	6
31	2
32	2
33	2
34	2
35	1
36	1
37	2
38	3
40	2
43	1

TOTAL 53

HISTOGRAM OF MON

LOW	HIGH	N
11.00	16.00	2
16.00	21.00	8
21.00	26.00	12
26.00	31.00	14
31.00	36.00	8
36.00	41.00	7
41.00	46.00	1



CASES INCLUDED 52 MISSING CASES 0

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
MON	28.13	7.024	52	28.50	13.00	43.00

FREQUENCY DISTRIBUTION OF TUE

VALUE	N
13	1
15	1
16	3
17	1
18	1
19	3
2Ø	2
21	3
22	5
23	6
24	6
25	3
26	4
27	3
28	3
29	2
3Ø	1
31	1
33	2
4Ø	1

TOTAL 53

HISTOGRAM OF TUE

LOW	HIGH	N
13.ØØ	17.ØØ	6
17.ØØ	21.ØØ	9
21.ØØ	25.ØØ	2Ø
25.ØØ	29.ØØ	12
29.ØØ	33.ØØ	4
33.ØØ	37.ØØ	Ø
37.ØØ	41.ØØ	1

CASES INCLUDED 52 MISSING CASES Ø

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
TUE	23.69	5.Ø12	52	23.5Ø	13.ØØ	4Ø.ØØ

FREQUENCY DISTRIBUTION OF WED

VALUE	N
11	1
12	1
14	1
16	1
18	4
21	6
22	8
23	5
24	4
25	3
26	1
27	2
28	4
29	3
31	2
32	1
34	2
36	1
37	1
40	1

NON-MISSING 52

HISTOGRAM OF WED

LOW	HIGH	N
8.00	13.00	2
13.00	18.00	6
18.00	23.00	19
23.00	28.00	14
28.00	33.00	6
33.00	38.00	4
38.00	43.00	1

CASES INCLUDED 52 MISSING CASES 0

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
WED	24.37	5.941	52	23.00	11.00	40.00

FREQUENCY DISTRIBUTION OF THU

VALUE	N
6	1
8	1
12	2
13	3
14	1
16	1
17	6
18	1
19	2
20	6
21	6
22	4
23	5
24	3
25	1
26	4
28	1
29	1
30	1
31	1
32	1

NON-MISSING	52
MISSING	1
TOTAL	53

HISTOGRAM OF THU

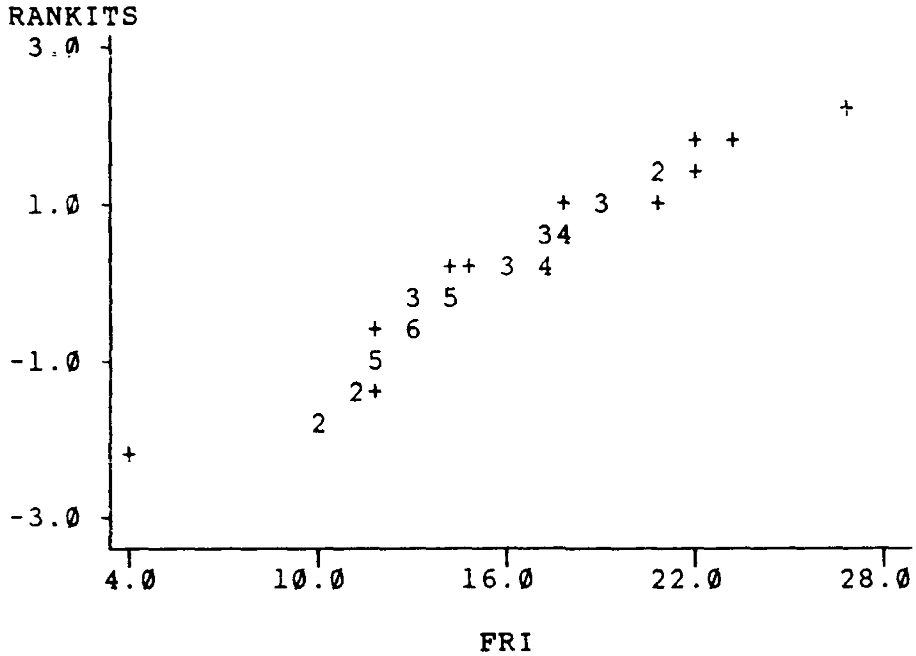
LOW	HIGH	N
5.00	9.00	2
9.00	13.00	5
13.00	17.00	8
17.00	21.00	15
21.00	25.00	13

CASES INCLUDED 43 MISSING CASES 0

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
THU	20.48	5.439	52	21.00	6.000	32.00

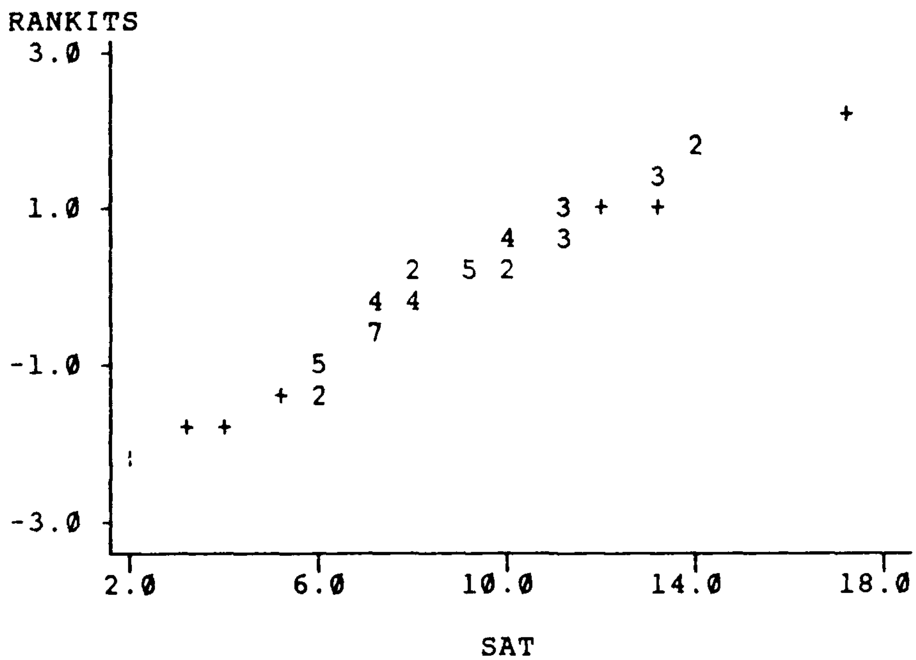
Tests for normality of total data.

RANKITS VS FRI



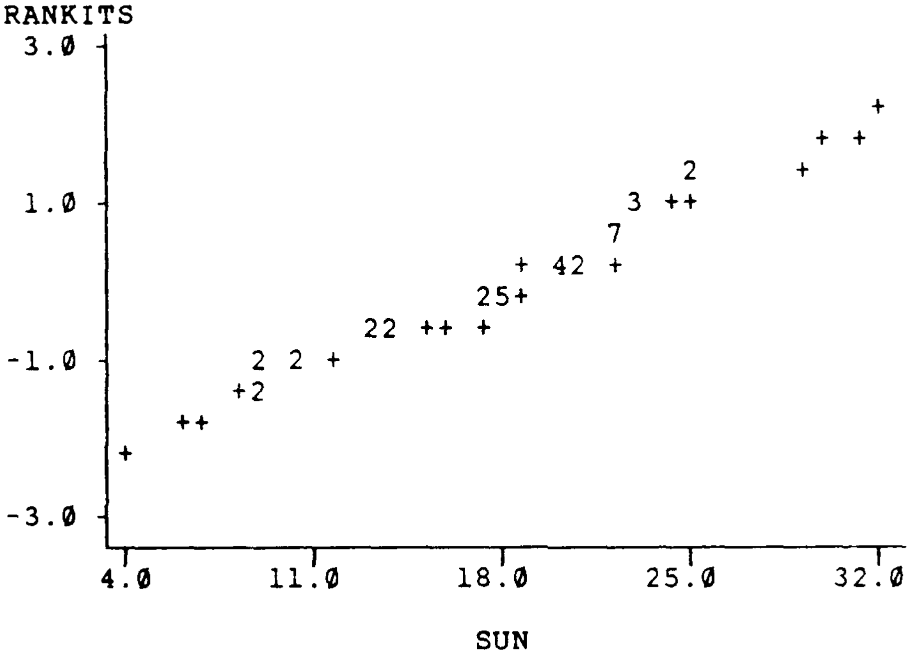
APPROX WILK-SHAPIRO 0.9504 53 CASES PLOTTED

RANKITS VS SAT



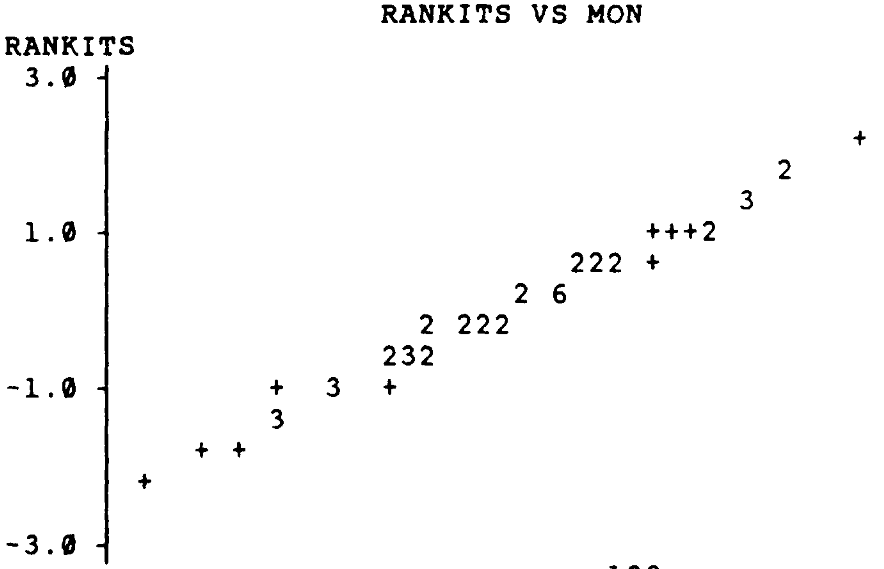
APPROX. WILK-SHAPIRO Ø.9667   53 CASES PLOTTED

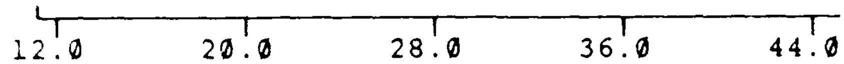
RANKITS VS SUN



APPROX. WILK-SHAPIRO Ø.9735   52 CASES PLOTTED

RANKITS VS MON

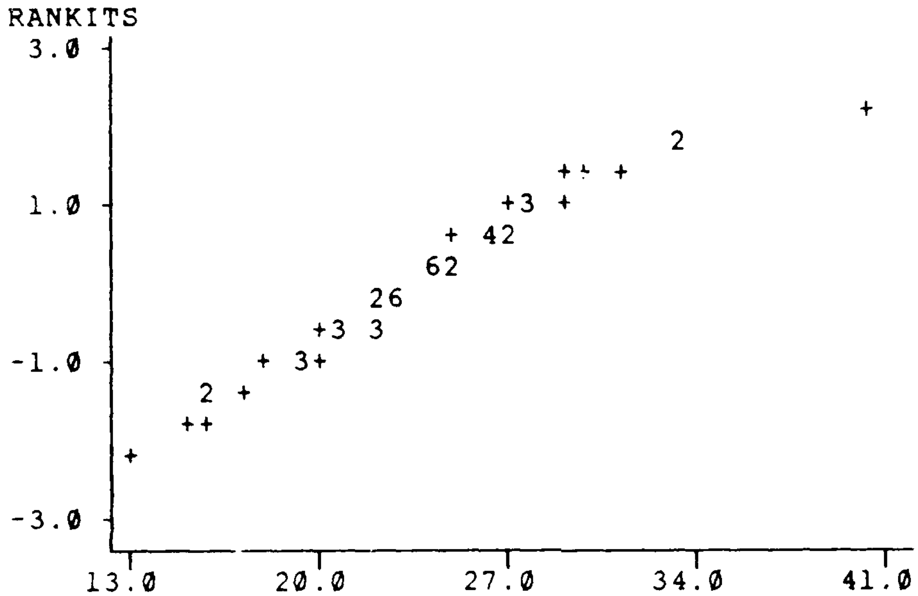




MON

APPROX. WILK-SHAPIRO 0.9908   52 CASES PLOTTED

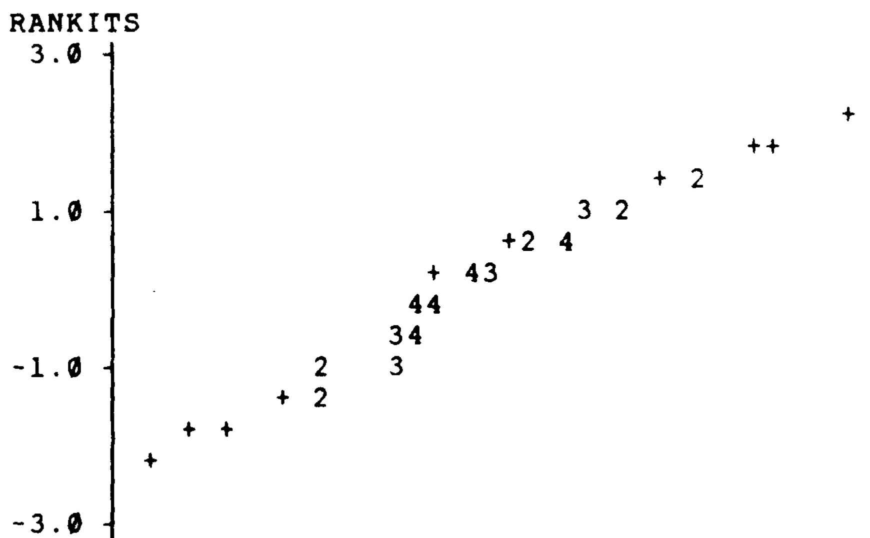
RANKITS VS TUE

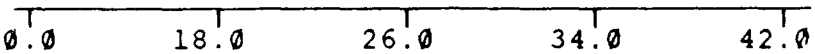


TUE

APPROX. WILK-SHAPIRO 0.9685   52 CASES PLOTTED

RANKITS VS WED

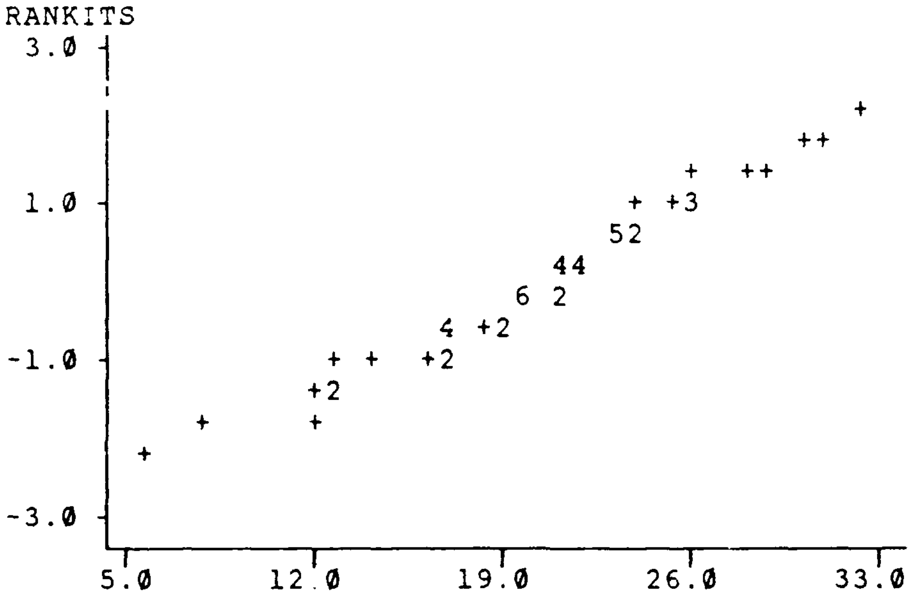




WED

APPROX. WILK-SHAPIRO 0.9671   52 CASES PLOTTED

RANKITS VS THU



THU

APPROX. WILK-SHAPIRO 0.9778   52 CASES PLOTTED

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
FRI	15.42	4.012	53	14.00	4.000	27.00
SAT	8.698	2.946	53	8.000	2.000	17.00
SUN	18.17	6.564	52	19.00	4.000	32.00
MON	28.13	7.024	52	28.50	13.00	43.00
TUE	23.69	5.012	52	23.50	13.00	40.00
WED	24.37	5.941	52	23.00	11.00	40.00
THU	20.48	5.439	52	21.00	6.000	32.00

APPENDIX G: UNSCHEDULED ARRIVALS ANALYSIS

The following are the Chi Square tests for the combination of Aero Evac and Emergency arrivals.

HO: Distribution is POISSON

HA: Distribution is not POISSON

Test stat: Chi Square statistic

Rejection Region: If Chi Square calculated is > Chi Square tabulated at alpha = .1, DF = K-1, reject HO.

All distrubtuions failed to reject HO, POISSON distribution was assumed.

CHI SQUARE TEST FOR FRIDAY UNSCHEDULED ARRIVALS

CHI SQUARE CRIT IS = 8.85
CHI SQUARE TAB IS = 12.02
ALPHA = .1, DF = 7, MEAN = 7.0

CHI SQUARE TEST FOR SATURDAY UNSCHEDULED ARRIVALS
CHI SQUARE CRIT IS = 7.4365
CHI SQUARE TAB IS = 9.236
ALPHA = .1, DF = 5, MEAN = 3.1

CHI SQUARE TEST FOR SUNDAY UNSCHEDULED ARRIVALS
CHI SQUARE CRIT IS = 3.7479
CHI SQUARE TAB IS = 10.64
ALPHA = .1, DF = 6, MEAN = 3.1

CHI SQUARE TEST FOR MONDAY UNSCHEDULED ARRIVALS
CHI SQUARE CRIT IS = 8.0336
CHI SQUARE TAB IS = 12.02
ALPHA = .1, DF = 7, MEAN = 5.0

CHI SQUARE TEST FOR TUESDAY UNSCHEDULED ARRIVALS
CHI SQUARE CRIT IS = 9.2469
CHI SQUARE TAB IS = 11.07
ALPHA = .05, DF = 5, MEAN = 2.4

CHI SQUARE TEST FOR WEDNESDAY UNSCHEDULED ARRIVALS
CHI SQUARE CRIT IS = 2.6263
CHI SQUARE TAB IS = 9.236
ALPHA = .1, DF = 5, MEAN = 2.4

CHI SQUARE TEST FOR THURSDAY UNSCHEDULED ARRIVALS
CHI SQUARE CRIT IS = 6.1265
CHI SQUARE TAB IS = 10.64
ALPHA = .1, DF = 6, MEAN = 2.6

Total percentages

	CCU	GYN	OB	MED	SURG	PED	ORTHO	MH
6995 =	144	503	1170	1825	2168	215	655	315
AVG	2.87	3.96	3.53	6.82	5.77	3.24	7.08	29.13
MAX	59	143	342	381	548	74	121	55
PERCENT	2.06%	7.20%	16.75%	26.13%	31.04%	3.08%	9.38%	4.51%

After outliers were removed.

Emergency percentages

	CCU	MED	SURG	GYN	OB	PED	ORTHO	MH
630 =	69	146	173	40	94	31	52	25
	10.92%	23.13%	27.48%	6.38%	14.83%	4.91%	8.30%	3.99%

Aero Evac percentages

	CCU	MED	SURG	GYN	OB	PED	ORTHO	MH
935 =	76	237	281	65	151	0	84	41
	8.09%	25.28%	30.03%	6.97%	16.21%	0.00%	9.07%	4.36%

Scheduled percentages

	CCU	MED	SURG	GYN	OB	PED	ORTHO	MH
	0.00%	26.57%	31.56%	7.32%	17.03%	3.39%	9.54%	4.59%
5430 =	0	1443	1714	398	925	183	517	249

The first percentage shows the total percentage of all arrivals. After that, percentages are shown for type of arrival and how many that percentages represents. Percentages vary by arrival because CCU and PED patients are not represented in all types of arrivals.

APPENDIX H: ANALYSIS OF LENGTH OF PATIENT STAY

Length of stay chi square tests for exponential distributions.

```
  FOR ALL DISTRIBUTIONS:

  HO: DIS IS EXPON
  HA: DIS IS NOT EXPON
  RR: IF CHI SQU CALC STAT > CHI SQUA TABLE VALUE AT:
    DF = K-1 AND ALPHA =.1, REJECT HO.

CHI SQUARE TEST FOR CCU
  CHI SQUARE CRIT IS =          7.9413
  CHI SQUARE TAB IS  =          9.236
  COUNT     138
  MEAN      2.87

CHI SQUARE TEST FOR GYN
  CHI SQUARE CRIT IS =           6.5756
  CHI SQUARE TAB IS  =           10.64
  COUNT     503
  MEAN      3.96

CHI SQUARE TEST FOR OB
 CHI SQUARE CRIT IS  =           5.5473
 CHI SQUARE TAB IS   =           6.251
  COUNT    1160
  MEAN     3.53

CHI SQUARE TEST FOR ORTHO
 CHI SQUARE CRIT IS  =             6.8804
 CHI SQUARE TAB IS   =             7.779
  COUNT     635
  MEAN     7.08

CHI SQUARE TEST FOR MEDICINE
 CHI SQUARE CRIT IS  =             6.8807
 CHI SQUARE TAB IS   =             7.779
  COUNT    1810
  MEAN     6.82

CHI SQUARE TEST FOR MENTAL HEALTH
 CHI SQUARE CRIT IS  =             6.849
 CHI SQUARE TAB IS   =             7.779
  COUNT    308
  MEAN    29.13

CHI SQUARE TEST FOR SURGERY
 CHI SQUARE CRIT IS    =           4.2487
 CHI SQUARE TAB IS     =           7.779
  COUNT    2193
  MEAN     5.77

CHI SQUARE TEST FOR PEDIATRICS
 CHI SQUARE CRIT IS    =             6.8573
 CHI SQUARE TAB IS     =             7.779
  COUNT     215
  MEAN     3.24
```

APPENDIX I: BED MANAGEMENT RESEARCH QUESTIONNAIRE

SUBJECT: Pretest 28 April 89

TO: Pretest group

1. You are one of twelve who has been specifically selected to receive this questionnaire 5 days before the rest of the Wright-Patt medical staff. The reason for this is that your perspective on the bed management issue may allow you to spot errors in this questionnaire before it is sent to the rest of the survey group. Your prompt reply will allow me to make corrections before sending out the final survey.

2. If your schedule allows, please complete this questionnaire promptly and return in the enclosed envelope. If your schedule does not allow a prompt reply, please return the questionnaire by 12 May 89. Your response will be given special attention either way.

Thank you,

R. DANIEL CHEEK, CAPT USAF
Graduate Student
Air Force Institute of Technology

WPMC/SGHB

Bed Management Questionnaire May 89

WPMC Staff involved with bed management

1. Please complete the attached questionnaire, and return it in the enclosed envelope to the Admissions and Dispositions office (SGRA) by Friday, 12 May 89.

2. This questionnaire measures certain WPMC professional staff's perceptions about the bed management process. The data gathered will become part of an AFIT research project and may be used to recommend changes to the bed management process. Your individual responses will be a key input for this study. Your response will be combined with others and will remain anonymous.

3. Participation is voluntary, but we need your help. For further information, contact Capt Dan Cheek at 5-4437, or 1 Lt Neil Meccia at 7-1343.

GERARD R. TUTTLE, Colonel, USAF
Director of Process Quality Review
Wright-Patterson Medical Center

2 Atch
1. Questionnaire
2. Return envelope

WPMC BED MANAGEMENT QUESTIONNAIRE

The purpose of this survey is to gather information from the Wright-Patterson Medical Center professional staff involved in the bed management process. All responses will remain anonymous.

General Instructions

1. Please answer each question. Select only one answer to each question unless directions state otherwise. It should take less than 10 minutes to complete the questionnaire. Your answers will be presented as grouped data to ensure your anonymity.

2. Responses will be machine scored so please mark your answers on the answer sheet provided. Use a No. 2 pencil. Blacken the appropriate circle, erase any stray marks, and don't fold the answer sheet.

3. Please use the comments section to elaborate on any dimension of the bed management process that we may have overlooked.

4. When you have completed the survey, please put the questionnaire and answer sheet in the envelope provided and return it to Admissions and Dispositions office (SGRA). Thank you for your participation.

DEFINITIONS

A "physician" is one whose primary responsibilities are to provide patient care.

An "administrator" is one whose primary responsibilities deal with establishing and maintaining policy for the hospital or for a department.

The term "bed management process" means the persons, policies, and procedures involved with processing inpatients into and out of beds.

PART I. This part of the questionnaire asks for background information. Questions will provide us with data on demographic information about respondents.

1. What is your age group?

    1. 21-30
    2. 31-40
    3. 41-50
    4. 51-60
    5. 61 and older

2. For active duty military, what is you military pay grade?

    1. O-1/O-2/O-3
    2. O-4/O-5
    3. O-6 and above
    4. Not applicable or civilian

3. What is your gender?

    1. Female
    2. Male

4. What is the highest educational degree you hold?

    1. Associate degree
    2. Bachelor's degree
    3. Master's degree
    4. Doctoral degree
    5. Other

5. How would you classify your current primary job?

    1. Physician
    2. Administrator - nurse
    3. Administrator - physician
    4. Administrator - other than nurse or physician
    5. Other

6. Which medical/clinical service are your primary duties associated with?

    1. Medicine
    2. Surgery (including oral surgery)
    3. Urology
    4. Orthopedic
    5. EENT
    6. Mental Health
    7. Pediatric
    8. OB/GYN
    9. Administration /other medical service

7. How many years have you served at Wright Patterson Medical Center?

   1. Less than 1
   2. 1 year but less than 2
   3. 2 years but less than 3
   4. 3 years but less than 4
   5. 4 years but less than 5
   6. more than 5 years

PART II. This part of the questionnaire asks your opinion of the bed management process at Wright-Patterson Medical Center. For each item, use the following scale to indicate how much you agree with each statement.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1	2	3	4	5

Respond to the remaining questions by answering the following question:

"The bed management process is made more difficult, in part, by ..."

8. ...hospital construction (as of 1 May 1989).

9. ...having too few beds (as of 1 May 1989).

10. ...the distribution of beds among medical services (as listed in question 6).

11. ...the inability to determine in advance the length of time a patient needs to remain in the hospital.

12. ...the failure of released patients to leave their rooms promptly.

13. ...patient factors, such as type of disease and gender, that make room scheduling difficult.

14. ...the staff to bed ratio limiting the number of available beds.

15. ...the effect of the Operating Room schedule on the admissions schedule.

16. ...physicians controlling access to beds.

For each item, use the following scale to indicate how much you agree with each statement.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1	2	3	4	5

Respond to the remaining questions by answering the following question:

> **"The bed management process is made more difficult, in part, by ..."**

17. ...the admissions office controlling access to beds.

18. ...the unpredictability of Aero Evac patient arrivals.

19. ...the unpredictability of emergency patient arrivals.

20. ...the Preadmissions Program.

21. ...a lack of more modern administrative technologies (such as computer scheduling programs).

22. ...no one being directly responsible for scheduling beds.

23. ...a lack of a scheduling procedure.

24. ...communication between Admissions/Dispositions and wards.

25. ...scheduling too many patients at a time.

26. ...a lack of a bed reservation system.

27. ...a lack of an accurate forecast of the number and type of patient arrivals.

28. ...the lack of an adequate information system.

29. ...communication between medical services (as listed in question 6).

30. ...hospital policies regarding medical evaluation boards.

31. ...hospital policies regarding use of beds.

32. ...the number of same day admissions patients.

33. ...the availability of critical care beds.

PART III. Open-Ended Question. Please respond to the question below.

34. Please describe any other problems concerning the bed management process that are not listed in the questionnaire or make any further comments that you wish.

Please return the questionnaire in the enclosed envelope to Capt Dan Cheek, care of the Admissions and Dispositions office (SGRA).

THANK YOU FOR YOUR HELP!

APPENDIX J: COMMENTS TO OPEN ENDED QUESTIONS

Comments on admissions

"The only serious problem I have had with bed management is when patients arrive from a distance and there is inadequate time to send them through preadmit. I have also had one or two patients who had trouble with beds when there was same day surgery."

"Preadmission cancellation reports never get incorporated into charts"

"Physicians and A&D clerks in themselves do not make the problem more difficult. These are, in fact, the parties most responsible for bed assignments. Also, keep in mind the role of nursing. We have physician bed coordinators, nurse-level coordinators all communicating to A&D personnel. My question is: I know that A&D personnel and nurse bed coordinators are involved but are the physician bed coordinators actively involved day to day. (sic)

"Does structure of organization inhibit the process? In a civilian hospital everyone reports to either administration or Director of Medical Service. Here, each corps has their own corps chief.

"Managing beds in a large teaching hospital with all the services available is a complex process. We are not yet adept at rapid turnover of patients or we have not had the same motivation as private hospitals. The Medical Board system with Air Force (not local hospital) requirements does slow down the discharge process, but we are getting better. "Bed utilization" needs specific individuals doing utilization review on a daily basis to start planning for discharge on day one. Present limitations ...is due to staffing, not construction or space.

"I don't know why the bed problem is so bad here compared to other bases I have been. I am only at the end of the line and don't know what the problems are. I have been told we don't have enough nurses and ward techs-but I don't know if that is the real problem.

"1. Promises to add nursing staff to maximize our bed utilization have not been forthcoming - not in the numbers required - and is an Air Force (not local) problem...

"This facility, by its nature, cannot be a "DRG" driven hospital and thus using "DRG" bed days will be a problem."

Comments on pediatrics

"Lack of designated true Pediatric wards for surgery/medicine patients. The adults on 2S hinder pediatric care and lead to admission squabbles. A dedicated pediatric floor would

1) Improve patient care
2) Decrease bed squabbles between GYN, surgery, ORTH, and Pediatric medicine.
3) Improve nursing morale
4) Eliminate adult transfers off 2s with the [increasing?] # of Pediatric patients.

If you don't want to commit to a Pediatric floor, do away with Pediatrics to avoid admission problems".

"Pediatrics has too many beds allotted-never seem to be full"

"Our major problem in pediatrics is lack of coordination on age related admissions. As we open new wards it is imperative that we tailor bed usage on 2s to pediatric age group patients with adequate staffing to support the various programs using the ward.

Now! Suggest:
1) Move GYN beds (6) to a new ward are.
(none of these patients will be pediatric age (<18 years)

Now! 2) Allocate those beds to: Orthopedics (2)-Pediatrics(3)-Surgery/Dental(1) all for patients < 18 years

July/Aug 89!
3) Restructure rest of surgical beds to > 18 years

Aug 89! 4) Open combined Medicine/Pediatrics close observation unit"

Comments on Medicine

Don't have enough medical beds

It is possible that medicine has too many beds and surgery does not have enough!"

Beds available to the surgical specialties are in great disproportion to those available to the medicine services.

Comments on Surgery

"lack of cooperation of one service letting the other use its beds Ex: medicine not letting surgery use their empty bed The practice of extending the patients hospitals stay for convenience sake rather than discharging patient home" [happens much too often]

"For my department. The MAJOR problem is filling all the beds with elective or scheduled patients. Our department has over 90% of admissions as acute and unpredictable. When the need arises-no beds are available. Also--surgery and/or A&D fills all Surgery beds with scheduled patients, and then wants one of our beds when they get an acute patient. There appears to be NO provision for acute, unscheduled admissions.

Comments on critical care

I am also aware of the severe problem with ICU beds not because I admit that many patients. to the ICU but because I am frequently consulted for problems which the patients develop".

"Critical Care bed availability is often a key decision maker for admission"

Our critical care units are grossly under staffed, as is the anesthesia department."

"Giving 'pre-admit' patients priority over patients waiting to move out of the Intensive Care Units. Intensive Care Unit patients should have 1st priority. Otherwise critically ill patients cannot be admitted because ICU beds fill up with non-critical patients. More "beds" are needed just for flexibility. The whole system bogs down when beds are tight and physicians have to spend time finding beds or waiting for patients to be admitted."

"Priority of bed availability should be unit ICD(ICU) transfer first."

Other

"Hire more nurses! Convert administrator slots to nursing slots! Contract out the hospital administration! "

"Asking nurses to manage more than one age group/type of patients and thus limiting the quality of care and the numbers of patients that can be taken care of [is a problem]."

"Many beds go unused because the patients are "out on pass". "Out on pass" is not allowed in the civilian sector for very good reasons. It is not cost effective. It should be eliminated for non-active duty patients. Either a patient needs to be in the hospital or he does not. It's that simple."

"Main problem is the lack of beds, i.e. the lack of enough support staff to open enough beds. This is followed closely by the lack of OR time -- to the lack of enough support staff to open all the OR".

"This is a major medical center. We need more beds and more nurses, more OR time. We don't need fancy computers to juggle what is an inadequate number of beds."

"I have not found a difficulty in managing admissions or obtaining beds".

"There should be a standing policy that emergency non-elective admissions take priority over all other admissions regardless of "service" bed availability. ie. if only surgery beds are available, but a pediatric patient needs admissions on an urgent or emergency basis, then that patient gets priority over all others without any inter-department (inter-service) communication necessary as is on elective admissions. Thanks".

"At Keesler the chief resident of each service is responsible for beds planning. It seems to get them to think more in terms of beds being a Medical Center Problem".

"In my opinion the biggest problem with this process is when physicians must call the wards to find a bed. This is time consuming and disruptive to clinic schedules. Having a designated bed nurse has been very helpful".

"Active duty should get priority after life/limb threatening emergencies regardless of medical service".

"OR Scheduling in regard to same day surgery vs preadmitted patients has forced our department to stop scheduling same day surgery."

"Physicians do not discharge patients early in the day per Medical Center policy".

"Real problems with bed situation:

1. too few beds
2. too few nurses
3. if #1 and #2 were addressed, there would not be a bed shortage problem"

<u>Additionally</u> a <u>Major</u> problem with getting patients into and out of the Emergency Room is waiting for bed availability. The Administration demands that patients be seen and either discharged or admitted with in 2 hrs. <u>Totally</u> impossible due to our current bed situation. Also the bed situation should be handled by non-physician administrators, etc."

"It shouldn't be necessary to get physician's permission to "give away" beds. If beds are available on one service and needed by another service, they should be used. It can be transferred back to service-specific wards as beds become available. Of course, each service should be assured of getting any and all patients in up to their limit. (i.e. patients should not be denied admission because so many service beds are occupied by patients from other services.)

"The question of Same Day Admissions should be considered since those patients are given priority in finding beds".

"Certain medical conditions require private rooms for optimal management--more private rooms would help--doubt that this is currently feasible. Long waiting times in admission office, especially afternoon."

"It is absolutely ludicrous for physicians to ever be given the task of having to locate their own beds for patients. This has happened too frequently in the past, although recently it seems to have improved."

"Pediatrics-2s
Two serious problems exist regarding the utilization of beds on our ward:

1) The type of adult patients placed on 2S. They are a "body" and often placed there without regard to type of illness and degree of nursing care involved! Our nurses are the ONLY ones in this hospital asked to care for a 2 week old and a 70 + year old GYN Oncology patient. The adult patients on 2S should be limited to those needing a minimum of nursing care/observation.

2) The propensity for another service to "borrow" a bed from Pediatrics and then when one of their patients is discharged another adult is put in that bed without Pediatrics being given their bed back.

"Tough problem with no easy answers".

APPENDIX K: QUESTIONAIRRE RESPONSES: RAW DATA

2	2	2	5	1	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	2	2	4	1	7	2	5	5	4	5	2	5	5	3	1	5	3	5	2	2	3	3	4	4	4	4	2	4	3	4	M	M
2	3	2	4	1	2	2	5	5	3	2	4	2	4	4	2	2	4	3	2	2	2	2	3	2	2	2	2	2	4	3	M	M
2	2	2	4	1	4	3	3	4	2	3	2	2	4	5	4	2	4	3	1	5	2	3	3	1	2	2	3	2	4	3	M	M
3	3	2	4	1	1	1	2	2	4	3	4	4	5	5	2	1	4	4	2	4	2	3	3	4	2	4	4	4	2	2	M	M
3	2	2	4	1	4	1	5	3	4	4	2	4	4	5	2	4	5	5	4	4	2	2	3	4	3	3	5	4	3	2	M	M
M	M	M	M	M	M	3	5	4	4	1	4	2	2	4	3	3	4	4	1	2	1	2	2	4	2	4	2	5	3	2	M	M
2	1	2	4	4	9	1	4	5	4	5	5	4	5	4	2	2	4	4	2	4	2	4	4	4	4	4	4	4	4	4	M	M
2	2	1	3	2	9	2	5	5	4	4	4	4	5	5	4	2	5	5	1	5	4	4	4	3	4	4	4	3	5	2	M	M
3	2	2	3	4	9	1	5	3	3	5	4	4	5	5	3	3	1	5	2	2	3	3	2	2	4	4	3	4	2	4	M	M
2	3	2	4	1	8	5	1	4	4	4	3	4	5	5	2	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
2	1	2	4	1	1	1	2	4	4	2	5	4	4	4	1	3	4	4	5	5	5	5	5	4	4	4	5	5	4	4	M	M
4	3	1	3	2	9	4	2	4	4	4	4	4	4	2	4	2	4	4	2	4	4	4	2	4	4	4	4	4	2	2	M	M
2	2	2	4	1	4	5	2	2	5	2	2	2	4	4	1	4	3	3	1	2	2	2	3	2	4	2	1	4	4	4	M	M
2	1	2	4	1	7	1	2	4	4	2	2	2	4	M	2	M	M	4	M	M	M	M	M	M	M	M	M	M	M	M	4	M
2	2	2	4	1	1	3	2	3	3	4	3	4	4	3	3	2	4	4	2	4	5	5	5	3	3	4	4	2	3	3	2	4
3	3	2	4	3	2	1	2	4	4	2	4	4	5	4	4	4	2	2	2	4	4	4	4	2	2	4	4	2	4	4	2	2
2	2	1	4	1	7	2	1	5	4	4	1	4	3	2	1	5	2	5	3	3	4	2	5	5	3	5	5	3	3	3	5	5
4	3	2	4	1	8	4	2	1	4	2	2	2	5	5	4	2	2	2	3	4	4	4	3	3	4	4	5	3	3	3	5	3
2	1	2	4	3	1	4	4	5	3	3	3	4	5	4	1	5	5	5	2	3	5	3	5	4	3	4	5	2	4	5	2	5
3	2	2	4	1	7	1	5	5	5	4	2	4	5	4	2	2	2	3	2	2	2	2	4	4	2	2	4	2	4	4	2	4
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2	2	1	4	1	2	1	4	5	4	4	4	3	3	5	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	5
4	4	2	5	4	7	6	4	4	4	5	4	4	4	4	4	4	5	5	4	5	4	4	4	4	4	4	4	4	5	4	4	4
2	2	2	4	1	7	2	4	4	4	4	2	4	4	2	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2	4
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3	3	2	5	2	9	6	4	5	5	3	4	5	5	5	3	5	3	5	4	5	5	4	5	5	5	5	5	3	5	4	4	5
2	1	1	5	1	1	4	3	4	3	5	3	4	5	5	1	2	5	5	2	4	4	4	4	4	3	4	4	3	4	4	3	4
3	3	2	4	1	8	5	5	3	5	4	5	5	5	5	4	3	4	4	3	5	5	2	2	2	5	5	5	5	5	5	3	5
2	2	2	4	1	1	6	2	5	3	1	4	4	5	4	2	4	4	4	3	3	3	3	4	4	4	4	3	2	2	3	3	2
2	2	2	4	1	1	3	4	4	3	2	3	5	5	3	2	2	5	5	2	3	3	3	3	2	3	4	5	3	2	3	3	5
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2	2	2	5	1	2	1	2	2	5	4	2	3	3	4	1	2	4	4	2	2	4	2	5	3	2	4	5	4	5	4	3	5
2	2	2	4	1	5	2	2	4	4	2	2	4	3	3	3	3	3	4	2	5	5	5	5	1	5	4	5	2	4	4	2	4
2	2	1	4	1	8	1	2	4	3	4	2	4	5	5	3	3	4	4	3	2	3	3	3	3	3	4	4	3	3	3	3	3
2	2	2	4	1	1	2	3	4	3	2	3	5	5	3	3	3	5	5	2	5	5	5	4	3	2	4	5	3	3	3	3	4
3	3	2	5	1	2	1	2	4	4	2	2	2	4	2	2	3	2	2	4	2	2	2	4	2	2	2	3	2	2	2	2	4
3	3	2	4	1	7	6	2	4	4	4	3	4	M	4	2	3	4	4	3	3	3	3	3	2	3	3	3	3	3	3	3	4
2	2	2	4	1	2	1	4	4	2	2	2	2	4	1	1	3	4	3	2	4	3	3	3	2	2	2	3	3	3	4	2	4
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2	2	2	4	1	1	6	3	5	4	4	5	2	5	4	1	4	3	4	4	3	3	3	4	3	4	3	3	3	4	5	3	5
3	3	2	4	1	2	6	5	5	1	5	4	4	5	4	1	1	4	5	1	5	2	2	2	2	5	5	5	4	2	2	1	2
2	2	2	4	1	2	2	5	5	4	4	3	3	4	4	2	2	4	3	2	3	3	3	4	2	4	3	4	3	2	4	2	5
3	3	2	4	1	1	5	2	4	2	3	2	2	5	4	2	2	4	2	2	2	3	3	2	3	2	4	2	2	2	2	2	5
2	2	2	4	1	1	3	2	5	4	3	1	4	5	3	1	4	5	3	2	4	4	3	3	3	5	5	5	3	2	2	2	4
4	3	2	4	3	2	6	5	5	1	5	4	3	2	4	3	4	3	5	3	5	2	2	4	2	4	3	5	2	2	2	4	4
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2	2	2	4	1	9	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	2	2	4	1	3	3	5	5	2	2	2	3	2	2	2	3	4	2	2	2	5	2	3	2	2	2	2	2	2	2	2	2
3	2	2	4	1	9	2	3	3	3	3	3	3	4	3	3	3	4	3	2	3	3	3	3	4	3	4	3	3	3	3	2	2
3	2	2	3	2	9	4	1	1	1	1	3	3	3	4	5	1	3	4	1	4	3	1	1	1	1	4	3	4	1	5	3	4
2	2	1	4	1	1	3	2	4	2	4	4	4	2	3	2	3	4	4	2	4	4	3	2	3	4	4	3	2	3	3	3	4
3	3	2	4	1	2	1	4	4	3	4	3	4	5	4	3	3	4	4	4	3	3	3	4	3	3	4	4	3	3	3	3	5
2	2	2	4	1	1	4	1	4	3	4	3	4	5	3	2	4	3	2	2	3	3	3	4	4	3	4	3	3	1	1	3	1
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2	2	2	4	1	2	3	4	5	4	4	3	4	4	2	2	4	5	3	2	5	5	4	4	3	3	3	4	4	4	3	2	5

APPENDIX L: SIMULATION PROGRAM CODE

```
DECLARE;
  GLOBALS: RUNLENGTH: INDEX:
           TFRIMEAN: TSATMEAN: TSUNMEAN: TMONMEAN: TTUEMEAN:
           TWEDMEAN: TTHUMEAN: MEDICINEBEDS: SURGERYBEDS: OBBEDS:
           ORTHOBEDS: GYNBEDS: MHEALTHBEDS: PEDBEDS: CCUBEDS:
           TIME_IN_MEDICINEQ OBSERVE_STATS:
           TIME_IN_SURGERYQ OBSERVE_STATS:
           TIME_IN_OBQ OBSERVE_STATS:
           TIME_IN_ORTHOQ OBSERVE_STATS:
           TIME_IN_GYNQ OBSERVE_STATS:
           TIME_IN_MHEALTHQ OBSERVE_STATS:
           TIME_IN_PEDQ OBSERVE_STATS:
           TIME_IN_CCUQ OBSERVE_STATS:
           TIME_IN_MEDICINEW OBSERVE_STATS:
           TIME_IN_SURGERYW OBSERVE_STATS:
           TIME_IN_OBW OBSERVE_STATS:
           TIME_IN_ORTHOW OBSERVE_STATS:
           TIME_IN_GYNW OBSERVE_STATS:
           TIME_IN_MHEALTHW OBSERVE_STATS:
           TIME_IN_PEDW OBSERVE_STATS:
           TIME_IN_CCUW OBSERVE_STATS:
           NUM_IN_SYSTEM TIME_STATS;
  ENTITIES:
                PATIENT(4);
                STRINGS: Running OF_SIZE 7:
                  MESSAGE OF_SIZE 37:
                  COMMENTS OF_SIZE 60:
                  BLANK OF_SIZE 3;
DEF_SCREEN: Questions,1,1,80,24, YES;
+
             WRIGHT-PATTERSON BED MANAGEMENT SIMULATION

   COMMENT:
   (Enter the appropriate data at the ?)                TOTAL   (EM+AE)

   Scheduled Patients for Sunday------------   -----(18.70) (3.40)
   Scheduled Patients for Monday------------   -----(28.13) (5.17)
   Scheduled Patients for Tuesday-----------   -----(23.69) (2.57)
   Scheduled Patients for Wednesday---------   -----(24.37) (4.65)
   Scheduled Patients for Thursday----------   -----(20.48) (3.13)
   Scheduled Patients for Friday------------   -----(15.42) (5.80)
   Scheduled Patients for Saturday----------   -----( 8.90) (3.44)
   Medicine Beds----------------------------   -----(51)
   Surgery Beds-----------------------------   -----(56)
   Labor & Delivery Beds--------------------   -----(18)
   Orthopedic Beds--------------------------   -----(16) *
   Gynecology Beds--------------------------   -----(11)
   Mental Health Beds-----------------------   -----(55)
   Pediatric Beds---------------------------   -----( 7) *
   Cardiology CCU Beds----------------------   -----( 7)
   Number of "Days" to Run------------------   -----(364)
   Enter 1 to start, 0 to re-enter data-----   -----
   * (reduced 25% to correct for ward 3 month ward closure)
DEF_SCREEN: Picture,1,1,80,25,YES;
```

```
+
                 WRIGHT-PATTERSON BED MANAGEMENT SIMULATION

   RUNTIME:          NUMBER IN SYSTEM:          TOTAL DISCHARGED:


   AEROEVAC  ARRIVALS:
   EMERGENCY ARRIVALS:
   SCHEDULED ARRIVALS:


    CLINIC   QUEUE       WARD                   BEDS SET

   MEDICINE:
   SURGERY :
   OB      :
   ORTHO   :
   GYN     :
   MHEALTH :
   CCU     :
   PEDS    :



 FILES: OUT,APPEND;

END;

PRERUN;

SCREEN, Questions,1,0,1,11,0;
SCREEN, Questions,0,1,0,9,0;

QuestionScreen
                ACCEPT, 12,4, COMMENTS;
                ACCEPT, 44,7, TSUNMEAN;
                ACCEPT, 44,8, TMONMEAN;
                ACCEPT, 44,9, TTUEMEAN;
                ACCEPT, 44,10, TWEDMEAN;
                ACCEPT, 44,11, TTHUMEAN;
                ACCEPT, 44,12, TFRIMEAN;
                ACCEPT, 44,13, TSATMEAN;

                ACCEPT, 44,14, MEDICINEBEDS,1;
                 WHILE, MEDICINEBEDS<> ROUND (MEDICINEBEDS);
                  SHOW, 45,14,MESSAGE,37,0,4,7;
                  SHOW,45,14,BLANK,3,0,9,0;
                   ACCEPT, 44,14, MEDICINEBEDS,1;
                 END_WHILE;

               ACCEPT, 44,15, SURGERYBEDS,1;
                WHILE, SURGERYBEDS<> ROUND (SURGERYBEDS);
                 SHOW, 45,15, MESSAGE,37,0,4,7;
                 SHOW, 45,15, BLANK,3,0,9,0;
                  ACCEPT,44,15, SURGERYBEDS,1;
                END_WHILE;
```

```
        ACCEPT, 44,16, OBBEDS,1;
         WHILE, OBBEDS<> ROUND (OBBEDS);
          SHOW, 45,16, MESSAGE,37,Ø,4,7;
          SHOW, 45,16, BLANK,3,Ø,9,Ø;
           ACCEPT,44,16, OBBEDS,1;
         END_WHILE;

        ACCEPT, 44,17, ORTHOBEDS,1;
         WHILE, ORTHOBEDS<> ROUND (ORTHOBEDS);
          SHOW, 45,17, MESSAGE,37,Ø,4,7;
          SHOW, 45,17, BLANK,3,Ø,9,Ø;
           ACCEPT,44,17, ORTHOBEDS,1,
         END_WHILE;

       ACCEPT, 44,18, GYNBEDS,1;
        WHILE, GYNBEDS<> ROUND (GYNBEDS);
         SHOW, 45,18, MESSAGE,37,Ø,4,7;
         SHOW, 45,18, BLANK,3,Ø,9,Ø;
          ACCEPT,44,18, GYNBEDS,1;
        END_WHILE;

       ACCEPT, 44,19, MHEALTHBEDS,1;
        WHILE, MHEALTHBEDS<> ROUND (MHEALTHBEDS);
         SHOW, 45,19, MESSAGE,37,Ø,4,7;
         SHOW, 45,19, BLANK,3,Ø,9,Ø;
          ACCEPT,44,19, MHEALTHBEDS,1;
        END_WHILE;

       ACCEPT, 44,2Ø, PEDBEDS,1;
        WHILE, PEDBEDS<> ROUND (PEDBEDS);
         SHOW, 45,2Ø, MESSAGE,37,Ø,4,7;
         SHOW, 45,2Ø, BLANK,3,Ø,9,Ø;
          ACCEPT,44,2Ø, PEDBEDS,1;
        END_WHILE;

       ACCEPT, 44,21, CCUBEDS,1;
        WHILE, CCUBEDS<> ROUND (CCUBEDS);
         SHOW, 45,21, MESSAGE,37,Ø,4,7;
         SHOW, 45,21, BLANK,3,Ø,9,Ø;
          ACCEPT,44,21, CCUBEDS,1;
        END_WHILE;

      ACCEPT, 44,22, RUNLENGTH;
      ACCEPT, 44,23, INDEX;
         BRANCH INDEX < 1 , QuestionScreen:
                          , NextScreen;

NextScreen
      SCREEN, Picture, 1,1,1,15,1;
      SCREEN, Picture, Ø,Ø,Ø,15,Ø;


{The model will run to bring the process to a steady state.  Then
the simulator will begin to collect statistics. }

      SET STOP_TIME:=RUNLENGTH+6Ø:
           MESSAGE:= 'The number must be an integer';
```

```
OPEN, OUT AS 'STANDARD.OUT';
WRITE, OUT,'MODEL PARAMETERS FOR RUN:':/:
       '   ':BLANK,3,Ø:/:
       'COMMENTS:':COMMENTS,6Ø,Ø:/:
       '   ':BLANK,3,Ø:/:
       'MEDICINE BEDS              :':MEDICINEBEDS,3,Ø:/:
       'SURGERY BEDS               :':SURGERYBEDS,3,Ø:/:
       'OB BEDS                    :':OBBEDS,3,Ø:/:
       'ORTHO BEDS                 :':ORTHOBEDS,3,Ø:/:
       'GYN BEDS                   :':GYNBEDS,3,Ø:/:
       'MENTAL HEALTH BEDS         :':MHEALTHBEDS,3,Ø:/:
       'PEDIATRICS BEDS            :':PEDBEDS,3,Ø:/:
       'CCU BEDS                   :':CCUBEDS,3,Ø:/:
       '    ':BLANK,3,Ø:/;

 CLOSE, OUT;

END;
DISCRETE;
       MONITOR
           MEDICINEBEDS: SURGERYBEDS: OBBEDS: ORTHOBEDS:
           GYNBEDS: MHEALTHBEDS: PEDBEDS: CCUBEDS:
           AEROEVACQ: EMERGQ: SCHEDQ: MEDICINEQ: OBQ: SURGERYQ:
           ORTHOQ: MHEALTHQ: CCUQ: GYNQ: PEDQ: MEDICINEW: OBW:
           SURGERYW: ORTHOW: MHEALTHW: CCUW: GYNW: PEDW:
           LastCall;

            SHOW,13,6,STIME-6Ø,4,2,15,1;
            SHOW,39,6,NUM_IN_SYSTEM,4,Ø,15,1;
            CHART,3Ø,9,2,ØØ1, NUM(AEROEVACQ),4Ø,13,1;
            CHART,3Ø,1Ø,2,ØØ1, NUM(EMERGQ),4Ø,13,1;
            CHART,3Ø,11,2,ØØ1, NUM(SCHEDQ),4Ø,13,1;
            SHOW,24,9,NUM(AEROEVACQ),3,Ø,15,1;
            SHOW,24,1Ø,NUM(EMERGQ),3,Ø,15,1;
            SHOW,24,11,NUM(SCHEDQ),3,Ø,15,1;
            CHART,17,16,2,ØØ1,NUM(MEDICINEQ),1Ø,13,1;
            CHART,17,17,2,ØØ1,NUM(SURGERYQ),1Ø,13,1;
            CHART,17,18,2,ØØ1,NUM(OBQ),1Ø,13,1;
            CHART,17,19,2,ØØ1,NUM(ORTHOQ),1Ø,13,1;
            CHART,17,2Ø,2,ØØ1,NUM(GYNQ),1Ø,13,1;
            CHART,17,21,2,ØØ1,NUM(MHEALTHQ),1Ø,13,1;
            CHART,17,22,2,ØØ1,NUM(CCUQ),1Ø,13,1;
            CHART,17,23,2,ØØ1,NUM(PEDQ),1Ø,13,1;
            SHOW,14,16,NUM(MEDICINEQ),2,Ø,15,1;
            SHOW,14,17,NUM(SURGERYQ),2,Ø,15,1;
            SHOW,14,18,NUM(OBQ),2,Ø,15,1;
            SHOW,14,19,NUM(ORTHOQ),2,Ø,15,1;
            SHOW,14,2Ø,NUM(GYNQ),2,Ø,15,1;
            SHOW,14,21,NUM(MHEALTHQ),2,Ø,15,1;
            SHOW,14,22,NUM(CCUQ),2,Ø,15,1;
            SHOW,14,23,NUM(PEDQ),2,Ø,15,1;
            CHART,3Ø,16,2,ØØ1,NUM(MEDICINEW),34,13,1;
            CHART,3Ø,17,2,ØØ1,NUM(SURGERYW),34,13,1;
            CHART,3Ø,18,2,ØØ1,NUM(OBW),34,13,1;
            CHART,3Ø,19,2,ØØ1,NUM(ORTHOW),34,13,1;
            CHART,3Ø,2Ø,2,ØØ1,NUM(GYNW),34,13,1;
            CHART,3Ø,21,2,ØØ1,NUM(MHEALTHW),34,13,1;
            CHART,3Ø,22,2,ØØ1,NUM(CCUW),34,13,1;
            CHART,3Ø,23,2,ØØ1,NUM(PEDW),34,13,1;
            SHOW,27,16,NUM(MEDICINEW),2,Ø,15,1;
```

```
SHOW,27,17,NUM(SURGERYW),2,Ø,15,1;
SHOW,27,18,NUM(OBW),2,Ø,15,1;
SHOW,27,19,NUM(ORTHOW),2,Ø,15,1;
SHOW,27,2Ø,NUM(GYNW),2,Ø,15,1;
SHOW,27,21,NUM(MHEALTHW),2,Ø,15,1;
SHOW,27,22,NUM(CCUW),2,Ø,15,1;
SHOW,27,23,NUM(PEDW),2,Ø,15,1;
SHOW,65,16, MEDICINEBEDS,3,Ø,15,1;
SHOW,65,17, SURGERYBEDS,3,Ø,15,1;
SHOW,65,18, OBBEDS,3,Ø,15,1;
SHOW,65,19, ORTHOBEDS,3,Ø,15,1;
SHOW,65,2Ø, GYNBEDS,3,Ø,15,1;
SHOW,65,21, MHEALTHBEDS,3,Ø,15,1;
SHOW,65,22, CCUBEDS,3,Ø,15,1;
SHOW,65,23, PEDBEDS,3,Ø,15,1;

END_MONITOR;

{This creates a patient to bring the simulation up to
a steady state.  }

        CREATE,1,PATIENT,Ø,6Ø,1;
        CLEAR;
        KILL;

         CREATE,NORMAL(TMONMEAN,7.Ø24,Ø),PATIENT,7,Ø, ;
{MON}    BRANCH,TSPLIT;
         CREATE,NORMAL(TTUEMEAN,5.Ø12,Ø),PATIENT,7,1, ;
{TUES}   BRANCH,TSPLIT;
         CREATE,NORMAL(TWEDMEAN,5.941,Ø),PATIENT,7,2, ;
{WED}    BRANCH,TSPLIT;
         CREATE,NORMAL(TTHUMEAN,5.439,Ø),PATIENT,7,3, ;
{THU}    BRANCH,TSPLIT;
         CREATE,NORMAL(TFRIMEAN,4.Ø12,Ø),PATIENT,7,4, ;
{FRI}    BRANCH,TSPLIT;
         CREATE,1+NORMAL(TSATMEAN,1.9Ø{2.946},Ø),PATIENT,7,5, ;
{SAT}    BRANCH,TSPLIT;
         CREATE,NORMAL(TSUNMEAN,5.2Ø{6.Ø6},Ø),PATIENT,7,6, ;
{SUN}    BRANCH,TSPLIT;

==============================================================
```

The second simulation was exactly the same as the first except arrivals were modeled as follows.

```
         CREATE,23+POISSON(5.Ø,Ø),PATIENT,7,Ø, ;
{MON}    BRANCH,TSPLIT;
         CREATE,21+POISSON(2.4,Ø),PATIENT,7,1, ;
{TUES}   BRANCH,TSPLIT;
         CREATE,22+POISSON(2.4,Ø),PATIENT,7,2, ;
{WED}    BRANCH,TSPLIT;
         CREATE,17.88+POISSON(2.6,Ø),PATIENT,7,3, ;
{THU}    BRANCH,TSPLIT;
         CREATE,8+POISSON(7.Ø,Ø),PATIENT,7,4, ;
{FRI}    BRANCH,TSPLIT;
         CREATE,6+POISSON(3.1,Ø),PATIENT,7,5, ;
{SAT}    BRANCH,TSPLIT;
         CREATE,16+POISSON(3.1,Ø),PATIENT,7,6, ;
{SUN}    BRANCH,TSPLIT;
```

```
====================================================================

TSPLIT     SPLIT,PATIENT,1,ARRIVAL;
           BRANCH,TSPLIT;

ARRIVAL    SET PATIENT(1):=STIME:
           NUM_IN_SYSTEM:= NUM_IN_SYSTEM +1;
           BRANCH .08, AEROEVACQ: .13, EMERGQ: .79, SCHEDQ;

AEROEVACQ  BRANCH .2428 , MEDICINE: .1621, OB: .2903, SURGERY:
           .0907, ORTHO: .0635, MHEALTH: .0809, CCU: .0697, GYN;
           {PEDIATRICS RECEIVED NO AEROEVAC}

EMERGQ     SET PATIENT (3):=STIME;
           BRANCH .0992, CCUQ: .2319, MEDICINEQ: .2748, SURGERYQ:
           .0938, GYNQ: .1483, OBQ: .0291,PEDQ: .0830,ORTHOQ:
          .0399,MHEALTHQ;

SCHEDQ     ACTIVITY (.50);
           SET PATIENT(3):=STIME;
           BRANCH .2657, MEDICINEQ: .1703, OBQ: .3156, SURGERYQ:
           .0954, ORTHOQ: .0459, MHEALTHQ: .0732, GYNQ:
           .0339, PEDQ;
           {ASSUMED CCU WAS NOT SCHEDULED}


MEDICINE    ACTIVITY (.50);
            SET PATIENT(3):=STIME;
MEDICINEQ   QUEUE, PATIENT(TYPE);
            CONDITIONS, NUM(MEDICINEW)<MEDICINEBEDS,
            MEDICINEQ,,MEDICINEQCALC;
OB          ACTIVITY (.50);
            SET PATIENT(3):=STIME;
OBQ         QUEUE, PATIENT(TYPE);
            CONDITIONS, NUM(OBW)<OBBEDS,
            OBQ,,OBQCALC;
SURGERY     ACTIVITY (.50);
            SET PATIENT(3):=STIME;
SURGERYQ    QUEUE, PATIENT(TYPE);
            CONDITIONS, NUM(SURGERYW)<SURGERYBEDS,
            SURGERYQ,, SURGERYQCALC;
ORTHO       ACTIVITY (.50);
            SET PATIENT (3):=STIME;
ORTHOQ      QUEUE, PATIENT(TYPE);
            CONDITIONS, NUM(ORTHOW)<ORTHOBEDS,
            ORTHOQ,, ORTHOQCALC;
MHEALTH     ACTIVITY (.50);
            SET PATIENT (3):=STIME;
MHEALTHQ    QUEUE, PATIENT(TYPE);
            CONDITIONS, NUM(MHEALTHW)<MHEALTHBEDS,
            MHEALTHQ,,MHEALTHQCALC;
GYN         ACTIVITY (.50);
            SET PATIENT(3):=STIME;
GYNQ        QUEUE, PATIENT(TYPE);
            CONDITIONS, NUM(GYNW)<GYNBEDS,
            GYNQ,,GYNQCALC;
CCU         SET PATIENT(3):=STIME;
CCUQ        QUEUE, FIFO;
            CONDITIONS, NUM(CCUW)<CCUBEDS,
            CCUQ,,CCUQCALC;
```

```
PED           ACTIVITY (.5Ø);
              SET PATIENT(3):=STIME;
PEDQ          QUEUE, PATIENT(TYPE);
              CONDITIONS, NUM(PEDW)<PEDBEDS,
              PEDQ,,PEDQCALC;

MEDICINEQCALC     SET TIME_IN_MEDICINEQ := STIME - PATIENT(3);
                  SET PATIENT(4) := STIME;
MEDICINEW         ACTIVITY .13+EXPON (6.82,1);
                  SET TIME_IN_MEDICINEW := STIME - PATIENT(4);
                  BRANCH, LastCall;
OBQCALC           SET TIME_IN_OBQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
OBW               ACTIVITY .13+EXPON (3.53,2);
                  SET TIME_IN_OBW := STIME - PATIENT (4);
                  BRANCH, LastCall;
SURGERYQCALC      SET TIME_IN_SURGERYQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
SURGERYW          ACTIVITY .13+EXPON (5.77,3);
                  SET TIME_IN_SURGERYW := STIME - PATIENT(4);
                  BRANCH, LastCall;
ORTHOQCALC        SET TIME_IN_ORTHOQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
ORTHOW            ACTIVITY .13+EXPON(7.Ø8,4);
                  SET TIME_IN_ORTHOW := STIME - PATIENT(4);
                  BRANCH, LastCall;
MHEALTHQCALC      SET TIME_IN_MHEALTHQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
MHEALTHW          ACTIVITY .13+EXPON(28.5,5);
                  SET TIME_IN_MHEALTHW := STIME - PATIENT(4);
                  BRANCH, LastCall;
GYNQCALC          SET TIME_IN_GYNQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
GYNW              ACTIVITY .13+EXPON(3.96,6);
                  SET TIME_IN_GYNW := STIME - PATIENT(4);
                  BRANCH, LastCall;
CCUQCALC          SET TIME_IN_CCUQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
CCUW              ACTIVITY .13+EXPON(2.87,7);
                  SET TIME_IN_CCUW := STIME - PATIENT(4);
                  BRANCH, LastCall;
PEDQCALC          SET TIME_IN_PEDQ := STIME - PATIENT(3);
                  SET PATIENT (4) := STIME;
PEDW              ACTIVITY .13+EXPON(3.24,8);
                  SET TIME_IN_PEDW := STIME - PATIENT(4);
                  BRANCH, LastCall;

LastCall          SET NUM_IN_SYSTEM := NUM_IN_SYSTEM -1;
                  KILL;
END;
CONTINOUS; END;
POSTRUN;
  REPORT;
CLEAR;
STOP;
END;
```

APPENDIX M: SIMULATION RESULTS

MODEL PARAMETERS FOR RUN:
COMMENTS:BASE RUN

MEDICINE BEDS	:	51
SURGERY BEDS	:	57
OB BEDS	:	18
ORTHO BEDS	:	16
GYN BEDS	:	11
MENTAL HEALTH BEDS	:	55
PEDIATRICS BEDS	:	7
CCU BEDS	:	7

SIMPLE_1

SIERRA SIMULATIONS & SOFTWARE:

SUMMARY REPORT FOR: the.BIN

GENERATED ON: 7/17/89 8:43:16 am
COMMENT:

SUMMARY REPORT: BLOCK STATISTICS

SIMULATED TIME: STIME = 4.2400000000E+02
STATISTICS CLEARED AT : 6.0000000000E+01

BLOCK LABEL	TYPE	AVERAGE	STD DEV	MIN	MAX	CRNT	CNT
ARRIVAL	SET	0.000	0.000	0	1	0	7069
AEROEVACQ	BRANCH	0.000	0.000	0	1	0	566
EMERGQ	SET	0.000	0.000	0	1	0	898
SCHEDQ	ACTIVITY	7.698	8.891	0	37	14	5605
MEDICINEQ	QUEUE	0.001	0.044	0	15	0	1856
OBQ	QUEUE	0.179	0.771	0	11	0	1156
SURGERYQ	QUEUE	0.000	0.000	0	16	0	2218
ORTHOQ	QUEUE	1.508	2.635	0	15	3	666
MHEALTHQ	QUEUE	0.000	0.000	0	5	0	319
GYNQ	QUEUE	0.033	0.266	0	5	0	501
CCUQ	QUEUE	0.000	0.000	0	4	0	142
PEDQ	QUEUE	0.000	0.021	0	3	0	212
MEDICINEW	ACTIVITY	36.362	5.003	20	51	39	1856
OBW	ACTIVITY	11.679	3.710	1	18	15	1156
SURGERYW	ACTIVITY	35.553	6.354	16	55	38	2218
ORTHOW	ACTIVITY	13.572	2.611	6	16	16	663
MHEALTHW	ACTIVITY	27.463	5.484	17	41	20	320
GYNW	ACTIVITY	6.021	2.427	0	11	5	501
CCUW	ACTIVITY	1.109	1.006	0	6	0	143
PEDW	ACTIVITY	1.846	1.457	0	7	1	212
LastCall	SET	0.000	0.000	0	1	0	7075

SUMMARY REPORT: OBSERVATIONAL STATISTICS

VARIABLE LABEL	TYPE	AVERAGE	STD DEV	MIN	MAX	CRNT	NO.
TIME_IN_MEDICINEQ	SCALAR	0.000	0.009	0.0	0.4	0.0	1856
TIME_IN_SURGERYQ	SCALAR	0.000	0.000	0.0	0.0	0.0	2218
TIME_IN_OBQ	SCALAR	0.057	0.209	0.0	1.8	0.0	1156
TIME_IN_ORTHOQ	SCALAR	0.821	1.335	0.0	6.0	2.1	663
TIME_IN_GYNQ	SCALAR	0.024	0.145	0.0	1.5	0.0	501
TIME_IN_MHEALTHQ	SCALAR	0.000	0.000	0.0	0.0	0.0	320
TIME_IN_PEDQ	SCALAR	0.001	0.009	0.0	0.1	0.0	212
TIME_IN_CCUQ	SCALAR	0.000	0.000	0.0	0.0	0.0	143
TIME_IN_MEDICINEW	SCALAR	7.063	7.070	0.1	55.5	8.3	1854
TIME_IN_SURGERYW	SCALAR	5.819	5.833	0.1	52.9	7.4	2225
TIME_IN_OBW	SCALAR	3.678	3.667	0.1	28.8	2.4	1153
TIME_IN_ORTHOW	SCALAR	7.367	6.870	0.1	51.3	11.7	659
TIME_IN_GYNW	SCALAR	4.358	4.063	0.1	24.2	6.7	507
TIME_IN_MHEALTHW	SCALAR	30.446	28.725	0.2	158.9	37.2	321
TIME_IN_PEDW	SCALAR	3.168	3.045	0.1	16.8	0.3	211
TIME_IN_CCUW	SCALAR	2.810	3.186	0.2	24.1	1.5	145

SUMMARY REPORT: TIME PERSISTANT STATISTICS

VARIABLE LABEL	TYPE	AVERAGE	STD DEV	MIN	MAX	CRNT
NUM_IN_SYSTEM	SCALAR	143.731	15.235	98.0	212.0	152.0

MODEL PARAMETERS FOR RUN:
COMMENTS:OPTIMUM RUN

MEDICINE BEDS	:	50
SURGERY BEDS	:	51
OB BEDS	:	22
ORTHO BEDS	:	27
GYN BEDS	:	14
MENTAL HEALTH BEDS	:	41
PEDIATRICS BEDS	:	7
CCU BEDS	:	6

SIMPLE_1

SIERRA SIMULATIONS & SOFTWARE:

SUMMARY REPORT FOR: the.BIN

GENERATED ON: 7/17/89 9:21:55 am
COMMENT:

SUMMARY REPORT: BLOCK STATISTICS

SIMULATED TIME: STIME = 4.2400000000E+02
STATISTICS CLEARED AT : 6., 00000000E+01

BLOCK LABEL	TYPE	AVERAGE	STD DEV	MIN	MAX	CRNT	CNT
ARRIVAL	SET	0.000	0.000	0	1	0	7069
AEROEVACQ	BRANCH	0.000	0.000	0	1	0	566
EMERGQ	SET	0.000	0.000	0	1	0	898
SCHEDQ	ACTIVITY	7.698	8.891	0	37	14	5605
MEDICINEQ	QUEUE	0.004	0.083	0	15	0	1856
OBQ	QUEUE	0.005	0.096	0	11	0	1156
SURGERYQ	QUEUE	0.004	0.096	0	16	0	2218
ORTHOQ	QUEUE	0.000	0.000	0	7	0	666
MHEALTHQ	QUEUE	0.000	0.000	0	5	0	319
GYNQ	QUEUE	0.001	0.023	0	5	0	501
CCUQ	QUEUE	0.000	0.000	0	4	0	142
PEDQ	QUEUE	0.000	0.021	0	3	0	212
MEDICINEW	ACTIVITY	36.362	5.001	20	50	39	1856
OBW	ACTIVITY	11.679	3.847	1	22	15	1156
SURGERYW	ACTIVITY	35.554	6.349	16	51	38	2218
ORTHOW	ACTIVITY	13.639	3.514	6	27	17	666
MHEALTHW	ACTIVITY	27.463	5.484	17	41	20	320
GYNW	ACTIVITY	6.020	2.465	0	14	5	501
CCUW	ACTIVITY	1.109	1.006	0	6	0	143
PEDW	ACTIVITY	1.846	1.457	0	7	1	212
LastCall	SET	0.000	0.000	0	1	0	7077

SUMMARY REPORT: OBSERVATIONAL STATISTICS

VARIABLE LABEL	TYPE	AVERAGE	STD DEV	MIN	MAX	CRNT	NO.
TIME_IN_MEDICINEQ	SCALAR	0.001	0.015	0.0	0.4	0.0	1856
TIME_IN_SURGERYQ	SCALAR	0.001	0.014	0.0	0.4	0.0	2218
TIME_IN_OBQ	SCALAR	0.002	0.019	0.0	0.3	0.0	1156
TIME_IN_ORTHOQ	SCALAR	0.000	0.000	0.0	0.0	0.0	666
TIME_IN_GYNQ	SCALAR	0.000	0.009	0.0	0.2	0.0	501
TIME_IN_MHEALTHQ	SCALAR	0.000	0.000	0.0	0.0	0.0	320
TIME_IN_PEDQ	SCALAR	0.001	0.009	0.0	0.1	0.0	212
TIME_IN_CCUQ	SCALAR	0.000	0.000	0.0	0.0	0.0	143
TIME_IN_MEDICINEW	SCALAR	7.063	7.070	0.1	55.5	8.3	1854
TIME_IN_SURGERYW	SCALAR	5.819	5.833	0.1	52.9	7.4	2225
TIME_IN_OBW	SCALAR	3.678	3.667	0.1	28.8	2.4	1153
TIME_IN_ORTHOW	SCALAR	7.372	6.867	0.1	51.3	14.6	661
TIME_IN_GYNW	SCALAR	4.358	4.063	0.1	24.2	6.7	507
TIME_IN_MHEALTHW	SCALAR	30.446	28.725	0.2	158.9	37.2	321
TIME_IN_PEDW	SCALAR	3.168	3.045	0.1	16.8	0.3	211
TIME_IN_CCUW	SCALAR	2.810	3.186	0.2	24.1	1.5	145

SUMMARY REPORT: TIME PERSISTANT STATISTICS

VARIABLE LABEL	TYPE	AVERAGE	STD DEV	MIN	MAX	CRNT
NUM_IN_SYSTEM	SCALAR	142.090	14.881	98.0	210.0	150.0

CCU BEDS

	SIM 1	SIM2
BEDS	WAIT IN DAYS	
4		1.1
5	0.7	0.0
6	0.0	0.0
7	0.0	

GYN BEDS

	SIM 1	SIM2
BEDS	WAIT IN DAYS	
11	1.5	
13	0.5	1.0
14	0.2	0.4
15	0.0	0.3
16		0.0

OB BEDS

	SIM 1	SIM2
BEDS	WAIT IN DAYS	
18	1.8	
21	0.7	
22	0.3	0.7
23		0.5
24	0.1	0.1
25	0.0	0.0

MEDICINE BEDS

	SIM 1	SIM2
BEDS	WAIT IN DAYS	
49	0.7	0.6
50	0.4	0.2
52	0.1	0.2
53	0.0	0.0

ORTHOPEDICS BEDS

BEDS	SIM 1 WAIT IN DAYS	SIM2 WAIT IN DAYS
16	6.0	8.6
22		0.8
23		0.0
25	1.1	
26	0.6	
27	0.0	

SURGERY BEDS

BEDS	SIM 1 WAIT IN DAYS	SIM2 WAIT IN DAYS
50	0.5	
51	0.4	
54	0.1	
55	0.0	
57	0.0	0.5
58		0.4
61		0.2
62		0.0

MENTAL HEALTH BEDS

BEDS	SIM 1 WAIT IN DAYS	SIM2 WAIT IN DAYS
35		2.8
36		0.0
40	2.2	
41	0.0	
55	0.0	0.0

PEDIATRIC BEDS

BEDS	SIM 1 WAIT IN DAYS	SIM2 WAIT IN DAYS
5	2.7	
6	0.6	1.7
7	0.1	0.6
8	0.0	0.2
9		0.0

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The purpose of this study was to analyze bed management at Wright-Patterson Medical Center. The research had three objectives: (1) Examine the admissions and dispositions process. (2) Determine the hospital staff's perspective on the problem. (3) Determine if the number of beds was adequate for demand. The research methodology consisted of interviews, a staff questionnaire, and a simulation study.

The research found some aspects of the admissions and dispositions process that were easing bed management problems. However, poor communication between departments as well as with patients, and lack of clear lines of authority and responsibility over the bed management process made bed management more difficult. The hospital staff generally agreed there were bed management problems, citing lack of personnel, inability to determine Emergency and Aero Evac arrivals, and not enough beds as major contributors to the problem. The simulation showed the Medical Center had enough beds to meet 1988 demand levels, and scheduling based on a historical mean would not improve bed usage. Some of the recommendations were to improve communication, return authority and responsibility for beds to the Admissions and Dispositions office, and begin a long term scheduling solution.